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**RESEARCH AND PRODUCTIVITY COUNCIL**
College Hill Road
P.O. Box 20000
Fredericton, N.B.
E3B 6C2
Telephone 506-452-8994 Telex 014-46115 Fax 506-452-1395

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# THE PETROLOGY, GEOCHEMISTRY AND MINERALOGY OF POTASH ORE MILL PRODUCTS FROM THE POTASH COMPANY OF AMERICA MINE AND THE DENISON POTACAN MINE

DSS Contract Serial No.
OSQ84-00443

For

Department of Energy, Mines and Resources
CANMET
Mineral Sciences Laboratories
555 Booth Street
Ottawa, ON
K1A 0G1

Attn: Dr. W. Petruk
Scientific Authority

CANMET
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Prepared by: John A.R. Stirling
Minerals and Fuel Technology

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# PART 1: INTRODUCTION AND ANALYTICAL METHODS

## 1.0 INTRODUCTION

The production of potash concentrate has become on of the major mineral commodities in New Brunswick. Potash is produced at the Potash Company of America Mine (PCA) (Roulston and Waugh 1983) and the Denison Potacan Potash Mine (Waugh and Urquhart 1983), both near Sussex. A third deposit in the Sussex area is under development by BP Canada (Hoffman et al 1987). The potash market is very competitive, therefore, it is essential that the mine and the concentrator operate at optimum conditions.

The New Brunswick Research and Productivity Council (RPC) prepared a proposal in response to a Supply and Services Canada request for proposal entitled "Mineralogical Studies of Potash Deposits" (DSS File No. 05SQ.23440-4-9232). The contract was awarded in March 29, 1985 (Contract Serial No.0SQ84-00443) and was due for completion July 31, 1988. The completion date was moved to March 31, 1989 because of equipment problems and sample procurement delays. A copy of Section 2.0 of the proposal entitled Proposed Program is given in Appendix A-1.

Samples of potash ore, host rocks, salt horses, and mill products were collected from the Potash Company of America and the Denison Potacan Potash Mine. There is a third deposit of potash in the Sussex area which was not studied because of the reluctance of the owner, BP Resources Canada, to participate in the project. The evaluation of the concentrators' performance, a better understanding of the geology of the deposits, and the development of mineralogical methods with which to predict the performance of the ore in the mill was achieved by quantitative mineralogical, and chemical and image analysis of the ore and mill samples.

During the course of the project several changes were made; multi-element analyses by ICP (Appendix A-1 Proposal Section 2.1.2) were not done because the inaccuracies of this method do not warrant the cost, fluid inclusion studies (Appendix A-1 Proposal Section

2.1.4) were not preformed because as the project progressed this was not deemed as important as other aspects of the project, and there were insufficient funds and time to evaluate another suite of mill samples after any changes made to a circuit (Appendix A-1 Section 2.2). Recommendations that are made are based on the samples collected during the study.

The results of this project are to remain confidential until the companies agree to their release. To maintain confidentiality the report will contain three Parts. Part 1, Introduction and Analytical methods and Part 2 and 3 for the presentation of the data and interpretations, for each mine. CANMET shall receive a complete report and each mine shall receive only their Part. Summaries of the project are included in Parts 2 and 3.

# PREMIERE PARTIE: INTRODUCTION ET METHODES ANALYTIQUES

## 1.0 INTRODUCTION

Le concentré de potasse est devenu un des principaux produits minéraux au Nouveau-Brunswick. La potasse est produite à la mine Potash Company of America (PCA) (Roulston et Waugh 1983) et à la mine Denison Potacan Potash (Waugh et Urquhart 1983), toutes deux situées près de Sussex. Un troisième gisement dans la région de Sussex est actuellement exploité par la BP Canada (Hoffman et autres 1987). Le marché de la potasse est très compétitif; il est donc primordial que la mine et le concentrateur fonctionnent dans des conditions optimales.

Le Conseil de la recherche et de la produtivité de Nouveau-Brunswick (CRP) a préparé une proposition en réponse à une demande de propositions du ministère des Approvisionnements et Services du Canada intitulée "Mineralogical Studies of Potash Deposits" (DSS réf.: 05SQ.23440-4-9232). Le contrat a été accordé le 29 mars 1985, "N° de série du contrat 0SQS84.00443) et devait être achevé le 31 juillet 1988. La date d'achèvement a été reportée au 31 mars 1989 en raison de problèmes d'équipement et de retards relativement au prélèvement d'échantillons. Un exemplaire de la partie 2.0 de la proposition intitulée Programme proposé est fourni à l'annexe A-1.

Des échantillons de minerai de potasse, de roches hôtes, de "salt horses" et de produits d'usine ont été prelevés à la Potash Company of America et à la Denison Potacan Potash Mine. Un troisième gisement de potasse dans la région de Sussex n'a pas été étudié parce que son propriétaire, Ressources BP Canada, était réticent à participer au projet. L'évaluation de la performance du concentrateur, une meilleure compréhension de la géologie des gisements et la mise au point de méthodes minéralogiques pouvant servir à prédire la performance du minerai à l'usine ont été atteints par des analyses minéralogiques, chimiques et d'image quantitatives des échantillons de minerai et d'usine.

Au cours du projet, plusieurs changements ont été apportés; il a été impossible d'effectuer des analyses multiélémentaries par ICP (annexe A-2 section 2.1.2 de la

proposition) parce que le manque de précision de cette méthode n'en justifie pas le coût; les études d'inclusion fluide (annexe A-1 de la section 2.1.4 de la proposition) n'ont pas été effectuées parce qu'au fur et à mesure que le projet progressait, elles n'ont pas été jugées aussi importantes que les autres aspects du projet, et on n'avait pas assez de fonds et de temps pour évaluer une autre série d'échantillons d'usine après tous les changements apportés au circuit (annexe A-1 de la section 2.2). Les recommandations proposées sont basées sur les échantillons prélevés au cours de l'étude.

Les résultats de ce projet demeurent confidentiels jusqu'à ce que les compagnies acceptent de les divulguer. Afin de respecter cette confidentialité, ce rapport sera divisé en trois parties. La première partie porte sur l'introduction et les méthodes analytiques, tandis que les parties deux et trois sont consacrées à la présentation des données et à leur interprétation, pour chaque mine. CANMET recevra le rapport intégral, tandis que chaque mine ne recerva que sa partie. Les résumés du projet sont inclus dans les parties deux et trois.

# 2.0 ANALYTICAL METHODS

## 2.1 Chemical Analysis

The chemical analyses were performed by the Department of Process Chemistry at RPC. K, Na, Ca, Mg, Rb, Sr, Fe, Mn, and Zn were analyzed by atomic absorbtion. The sample was prepared by treating 0.20 g with 10 ml of 1:1 $HNO_3$ and diluting to 100 ml. For K and Na the solutions were further diluted by a factor of 50. For Ca, Mg, Rb and Sr, 10 ml of the original solution plus 1.0 ml of a 10% Cs solution was used. The original solution was used for Fe, Mn and Zn.

The Volhard Method was used to determine Cl. Five ml of 1:1 $HNO_3$ and 100 ml $H_2O$ was added to 10 ml aliquots of the original (above) solution. To this 5.0 ml 0.1 N $AgNO_3$ and 5.0 ml saturated $Fe_2(SO_4)_3$ was added and backtitrated to a brownish endpoint with 0.05 N KCNS. The Cl concentration was calculated from excess $AgNO_3$.

Br was determined by X-ray fluorescence with a LiF crystal at a peak 30.28 degrees and background at 33.10 degrees. Br standards were prepared for 100, 500, 1000, and 2000 ppm Br. Both the standards and samples were prepared as pressed discs. (It was not necessary to use a binder.)

For B, $SO_4$ and insolubles, 5.0 g of sample was added to 5.0 ml of concentrated HCl and heated. This was filtered through a pre-weighed glass fiber filter and diluted to 200 ml. The pH was adjusted to 1.5 and further diluted to 250 ml. For B an aliquot of the prepared sample was evaporated in the presence of curcumin which formed the red coloured rosocyanine. After drying the colour was absorbed with alcohol and compared to standards photometrically. For $SO_4$ a turbidimetric method was used. An aliquot of sample was combined with a buffer solution and $BaCl_2$ was added to form $BaSO_4$ precipitate which was measured using turbidimeter and compared to standards. The insolubles were determined by weighing the filter used above.

The reproducibility of the method is demonstrated in Table 1 which gives the results of serval analyses of an in-house standard.

## 2.2 Mineral Analysis

In order to evaluate a mill circuit by quantitative mineralogy, it was necessary to measure the grain size of the phases present, their modes, their relations and their liberation. In the case of sylvinite, three main phases were to be considered; halite, sylvite, and insolubles which include anhydrite, clay minerals, and trace amounts of oxides and sulphides. In this study only halite and sylvite were studied by automated image analysis. The insolubles were much finer grained than the sylvite and halite, and comprise less than 5% of the ore. The grain size difference caused a problem of scale. At the low magnification of the image analysis system, which was necessary to study the halite and the sylvite, the insolubles were usually not observable or could be confused with background noise.

Both the ore and mill samples were studied so that a correlation could be made between the mineralogy of the ore and the mill products. Special techniques had to be developed to prepare polished thin sections and grain mounts because of the solubility of halite and sylvite in water and their softness.

In thin section and polished grain mounts, sylvite and halite cannot be readily distinguished from one another with the optical microscope (Figure 1), but can be readily distinguished from each other in the backscattered electron image (Figure 2).

Potash ores are coarse grained and when observed with standard optical or electron microscopes the field of view is too small to display a single ore particle in a coarse-grained screened fraction. Therefore it was necessary to develop methods to observe the samples at low magnification.

### 2.2.1 Sample Preparation

When ore samples were collected they were immediately placed in plastic bags to prevent sample degradation by high humidity. Halite will deliquesce at a relative humidity greater than 60%. The samples were stored in a dehumidified room.

A method was developed for the preparation of large (75 X 50 mm) polished thin sections of sylvinite. A slab, approximately 2 cm thick was cut from a rock sample with a metal band saw. One surface of the slab was ground flat on a lap covered with various grades of emery paper. The grinding was done dry with the exception of the fine-grinding when lapping oil was used. The surface was then polished on diamond laps. This surface was glued to a glass slide with UV-curing epoxy (Norland Optical Adhesive 61, available in Canada from Laser Fibre Optics Canada Ltd., Nepean). The sample was then held with a vacuum chuck and ground to the desired thickness and polished on diamond laps. The sections were thicker than normal in order to observe fluid inclusions and to keep them from breaking apart. Generally, they were made one layer of grains thick.

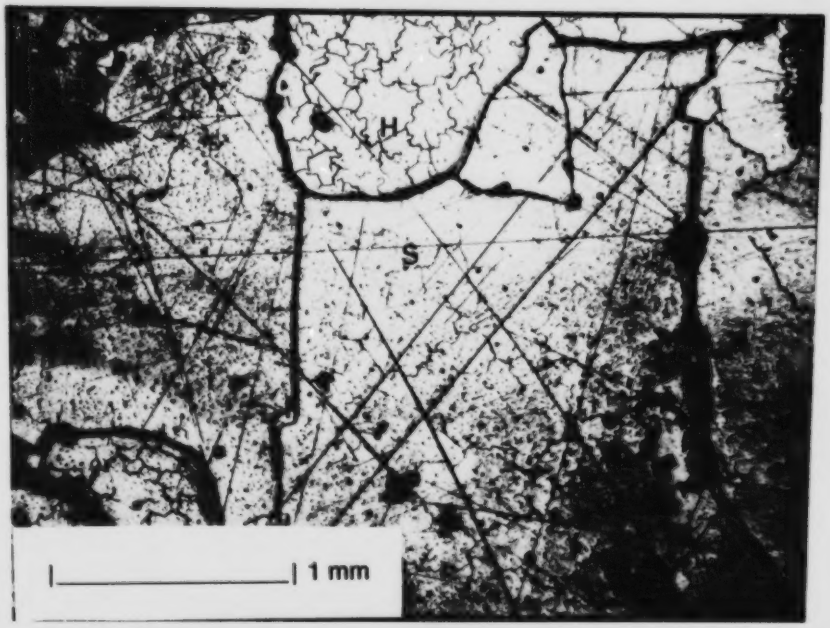



**FIGURE 1** Photomicrograph of sylvinite. Polished thin section of sylvinite viewed in plane polarized light. (H-halite, S-sylvite).

**FIGURE 2** Backscattered electron image of sylvinite. (H-halite, S-sylvite).

## TABLE 1

Repeated chemical analyses of the in-house standard.

| SAMPLE | | | | | | | | | | | | | | | NO OF | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WT% | | | | | | | | | | | | | | 5047 | ANAL. | AVE. | s.d. |
| K | 24.67 | 23.91 | 22.90 | 23.80 | 22.90 | 23.62 | 23.92 | 22.55 | 24.59 | 23.69 | | | | 22.23 | 11 | 23.53 | .75 |
| CA | .16 | .13 | .18 | .14 | .13 | .15 | .19 | .11 | .15 | .10 | | | | .14 | 11 | .14 | .03 |
| NA | 18.82 | 19.68 | 19.84 | 19.54 | 19.91 | 19.56 | 19.34 | 20.15 | 18.90 | 19.50 | 19.30 | 18.70 | 20.49 | 20.08 | 14 | 19.56 | .50 |
| CL | | | | | | | | | | | | | | 51.00 | 1 | 51.00 | |
| SO4 | .31 | .32 | .27 | .35 | .24 | | | | | | | | | | 5 | .30 | .04 |
| INSOLUBLES | | | | | | | | | | | | | | 5.66 | 1 | 5.66 | |
| PPM | | | | | | | | | | | | | | | | | |
| MG | 358 | 328 | 351 | 340 | 366 | 298 | 356 | 346 | 331 | 379 | 364 | 333 | 378 | 366 | 14 | 350 | 21 |
| FE | 1200 | 1324 | 1369 | 1364 | 1352 | 1345 | 1184 | 1079 | 1106 | 1164 | 2000 | 1895 | | 1399 | 13 | 1368 | 268 |
| MN | <10 | 0 | 14 | 0 | 11 | 14 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | <10 | 14 | 4 | 6 |
| ZN | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 14 | 0 | N/A |
| BR | 930 | 970 | 1010 | 1050 | 950 | 980 | 980 | 960 | 990 | 990 | | | | 886 | 11 | 972 | 41 |
| SR | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | | | | <10 | 11 | 0 | N/A |
| RB | 16 | 25 | 24 | 29 | 27 | 11 | 13 | <10 | 20 | 17 | 25 | 32 | <20 | 19 | 14 | 18 | 6 |
| B | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 10 | 8 | 11 | 9 | 11 | | | 12 | 9 | 1 |
| TOTAL | 44.21 | 44.31 | 43.47 | 44.11 | 43.45 | 43.60 | 43.70 | 43.05 | 43.89 | 43.55 | 19.54 | 18.93 | 20.53 | 99.38 | | 100.46 | .37 |

Sylvinite does not easily polish and the disturbed layer is quite noticeable. Therefore, in order to improve the polish, the samples were polished on a cloth saturated with alcohol. Both sylvite and halite are slightly soluble in alcohol and this polish (etching) removes the disturbed layer. Also, this polishing enhances the grain boundaries and the relief between halite and sylvite. Halite is slightly more soluble in alcohol than sylvite, which results in a slight relief difference.

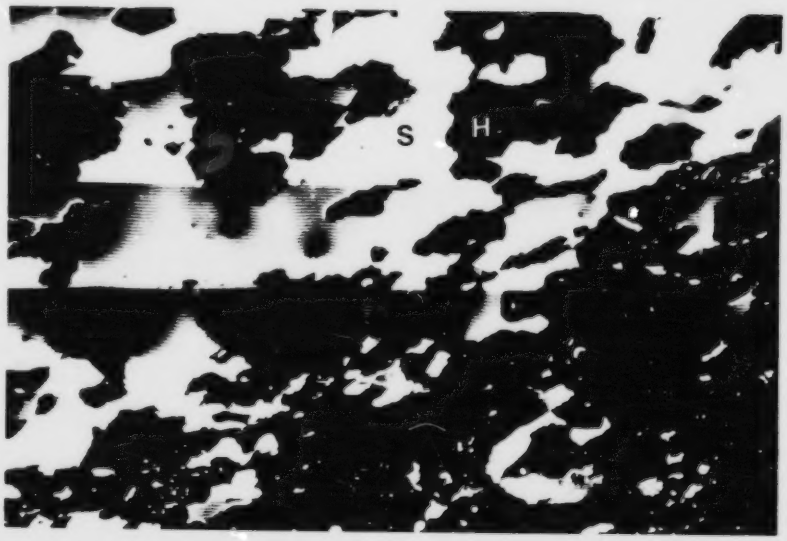
Samples of the slurry were collected for study and prepared for analysis as follows: the slurry was dewatered by standard methods and the residual brine was removed by two washings of 500-700 gm of ore in 500 ml of trichlorethan which in turn was removed by rinsing with methanol. The methanol was removed by either drying while mixing the sample or, if a suitable space was available, by burning off the methanol. For the liberation study the samples were sieved into various size fractions (Petruk et al 1986).

### 2.2.2 Low Magnification Imaging Techniques

The grain size of both the ore and the mill samples can range from 20 microns to 1 cm. At the lowest magnification of the microprobe (X40 magnification) only parts of a mineral grain or ore particle can be observed in a given image. By reducing and combining adjacent images with the image analyzer a photo mosaic of the large grains or ore particles can be produced. This was achieved by storing an image, moving the sample stage one image width, and collecting and storing the next image. A series of adjacent images was thereby collected and stored. The images were compiled into a mosaic using the zoom feature of the image analysis program. The mosaic image was then processed. Routines were developed which resulted in X20, X10, and X5 mosaic images. Figure 3 is a X5 mosaic image of a polished thin section of potash ore.

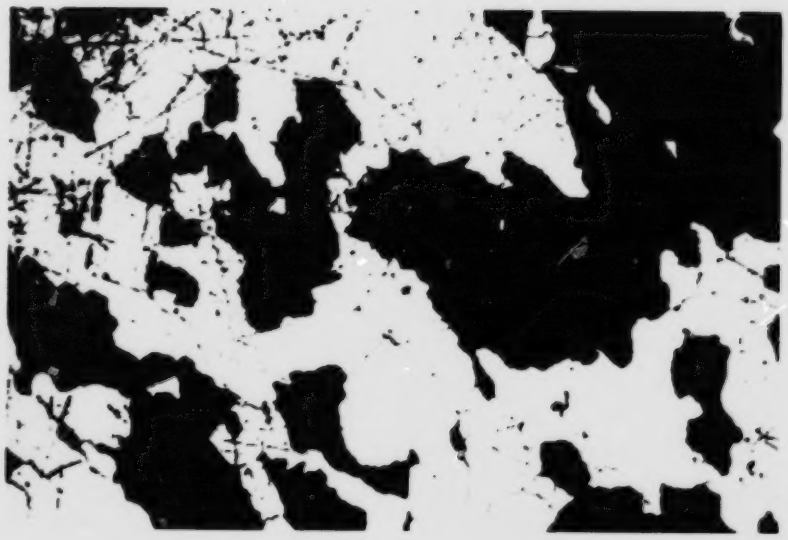
### 2.2.3 Grain Size Measurement of Sylvinite

One of the disadvantages of backscattered electron images is that the grain boundaries between the same minerals cannot be seen. The final polishing of the polished thin sections with a cloth saturated in alcohol does enhance the grain boundaries by an increase in the dissolution rate at grain boundaries, however, the backscattered image is dependent on composition. On the other hand the secondary electron image is the result of surface features. By combining the two images it was possible to produce an image which showed the compositional differences and some of the grain boundaries (Figure 4). These partial grain boundaries were reconstructed by using a grain boundary reconstruction program (Figure 5).




|_____| 2 mm

**FIGURE 3** A X5 mosaic backscattered image of sylvinite. The image is a combination of secondary and backscattered electron images of a polished thin section of sylvinite. The different shading occurs because the secondary electron image is not uniform across a single frame and it was used to demonstrate that the photo is mosiac.



|_____| 1 mm

**FIGURE 4** Binary image of sylvite with partial grain boundaries.

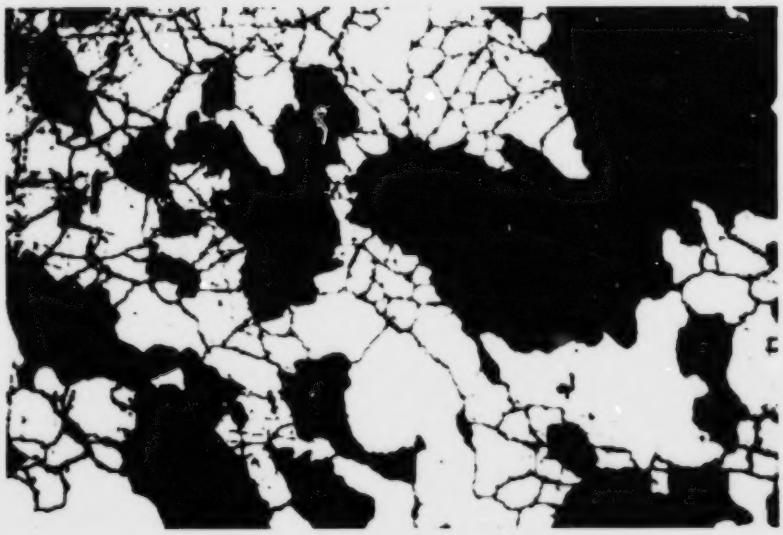


**FIGURE 5** Binary image of sylvite with grain boundaries completed reconstructed.

Minerals do not always break across grain boundaries, particular when they are easily cleaved such as sylvite and halite. When the grain size of the sylvite and halite was measured the resulting grind prediction was not correct when compared to the data for the mill samples. To overcome this problem chord measurements were made. The chord length of a sample is the length of a horizontal line across the sample (sylvite). Chord measurements were collected from evenly spaced lines across the sample (Figure 6) and the spacing of the lines was such that a grain contained several lines. These data were more comparable to the data for the mill samples. A good correlation was achieved by squaring the accumulated chord lengths and subtracting 0.5 from the log of the size fraction for cumulative grain size plots. This arbitrary correction factor was the same for both deposits.

### 2.2.4 Identification of Clay Minerals

Each of the samples were dispersed in deionized water and a de-flocculant was added when required (one part Sparkleen to three parts sample). Oriented samples were prepared for each sample by decanting on to glass slides after 1 minute, 5 minutes, and in some cases after 10 minutes, 35 minutes, and 1 hour. The samples were analyzed using a Philips high angle x-ray diffractometer with Cu radiation, a graphite monochromator and a variable front slit. The samples were analyzed in their natural state, after ethylene glycol treatment at 80 degrees Celsius for one hour, heating to 500 degrees Celsius for one hour and 700 degrees Celsius for one hour.

The XRD analyses of the clays were performed at the Department of Geology, University of New Brunswick.

### 2.2.5 Equipment, Operating Conditions and Standards

The image analysis was performed with a JEOL 733 electron microprobe operated at 15 KV and 10 nA, which was interfaced to a Kontron automated image analyzer.

The electron microprobe analysis for Br was performed at 15 KV and 10 nA with wavelength dispersive spectrometers and counting times up to 100 seconds. The counts were processed using a ZAF correction program. Halite and a KBr UV window were used as standards. For the analysis of boron minerals, the operating conditions were 10 KV, 50 nA and 20 seconds maximum counting time, and a PRZ correction program. The standards used were boron nitride, dolomite, rhodocrosite, hematite, calcite, and sylvite.

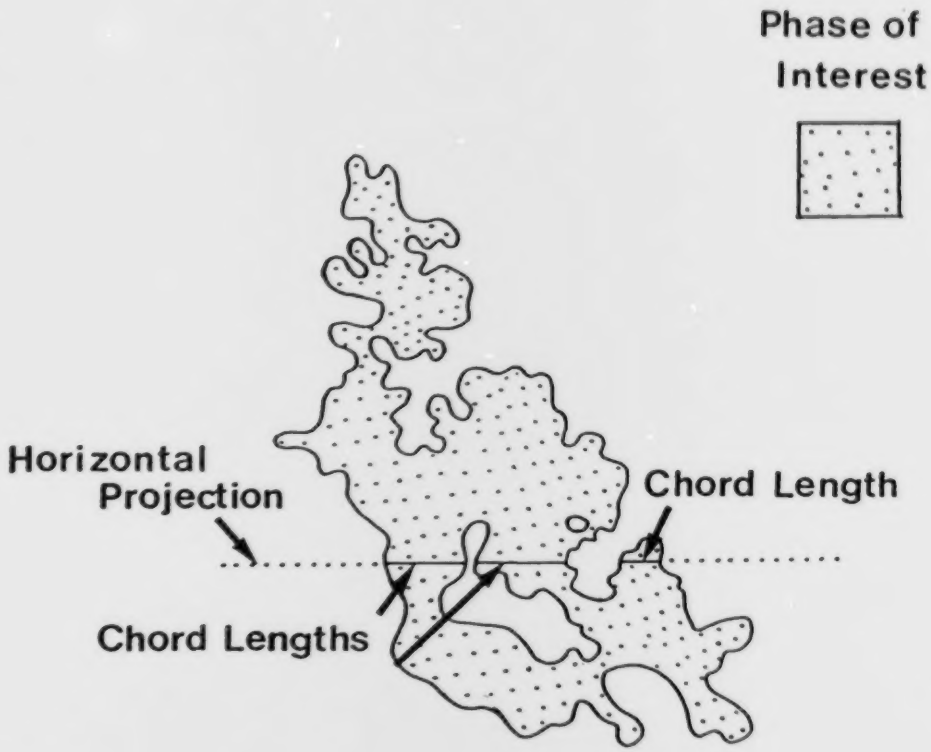



**FIGURE 6** Chord length measurements. A chord length measurement is the length of line which intersects the phase of intrest along a horizontal projection. Several chord measurements may be collected along one projection as seen in the diagram above. The chord lengths are collected along evenly spaced horizontal projections.

## 4.0 ACKNOWLEDGEMENTS

This project was funded by the Canada/New Brunswick Mineral Development Agreement. Dr. W. Petruk, Head, Mineral Sciences Laboratories, CANMET was the Scientific Authority for the project. Julie Melluish and Lech Lewczuk of RPC helped in the data acquisition, Peter Ormandy prepared the samples and helped develop the sample preparation procedures, and Dr. D. Abbott, Manager of Research and Development, reviewed the final report. The cooperation of Brain Roulston of PCA and Dave Waugh of Denison Potacan is acknowledged. Dr L. T. Tembath, and his students, Craig Hickey and Peter Burns of the Department of Geology, University of New Brunswick carried out the XRD analysis of the clay minerals. Peter Burns did the boron mineralogy as an undergraduate thesis.

# APPENDIX A-1
# THE PROPOSED PROGRAM

## 2.0 PROPOSED PROGRAM

The project will follow the guidelines given in Appendix A-1. The project can be divided into two phases:

1. mineralogical and chemical characterization of the potash deposits, and
2. beneficiation of the ore.

### 2.1.0 Mineralogical and Chemical Characterization of Potash Deposits

In co-operation with the mine geologists and New Brunswick Department of Natural Resources geologists, a series of representative samples will be collected from the mines and drill core. Selected samples will be collected for specialized studies, such as the occurrence of salt horses, fluid inclusion studies, clay mineralogy and mineral textures. Approximately 300 samples will be collected. Petrographic and chemical analysis will be made for most of the samples.

### 2.1.1 Mineralogical Analysis

Petrographic descriptions will be made for the polished slabs or thin sections of the samples. This will also include grain size and shape determination by automated image analyses (AIA). Mineral composition, identification, and fine textures will also be determined by microprobe and SEM/EDS (scanning electron microscopy with an energy dispersive system).

Special storage conditions and sample preparation are necessary because of the hygroscopic properties of halite, sylvite and other salt minerals (for example sylvite become hygroscopic at <60% relative humitidy). The samples must be kept in sealed polyethylene bags and stored in a low humidity environment. Polished slabs and thin sections must be prepared by an oil or dry method. A dry method which was developed by the author during previous salt projects [1] will be used.

### 2.1.2 Chemical Analysis

All of the samples will be chemically analyzed in duplicate for major and trace elements. For this study the major elements are as follows: Na, K, Ca, Cl and $SO_4$. The trace elements are: Fe, Mg, Mn, Rb, Br, Sr, B and $CO_3$, Organic C, $H_2O$ and L.O.I. (loss on ignition).

A few samples will undergo a semi-quantitative multi-element analysis by ICAP (inudced coupled plasma) or neutron activation analysis. Analytical and sample preparation methods developed over a three year period by the author during a previous salt project along with other standard methods will be used.[1]

Bromine is one of the more important trace elements in an evaporitic sequence. The concentration and distribution is useful for genetic and exploration purposes. It is a very difficult element to analyze routinely by the standard method. We propose that an XRF method be developed. In order to use XRF a set of reference standards are necessary. These standards will be analyzed by delayed neutron activation which is a more accurate and precise method than XRF, however, too expensive for routine analyses.

As explained in the previous section, the samples must be kept dry during and after pulverization. They must be stored in sealed polyethylene bottles. Even weighing must be done in a low humidity environment.

1 Stirling, J.A.R., Kashani, B.G, and Nance, D., 1982: Geochemistry of Selected Rocks, Vacherie Salt Dome, Louisiana. Institute for Environmental Studies, Louisiana State University, Baton Rouge, Topical Report No. E530-02200-T-8, 109 p., In Press.

### 2.1.3 Salt Horses

Areas of nearly pure halite called salt (halite) horses occur within the sylvite ore. Very little is known about the salt horses as to their genesis and distribution within the ore body so as they can be avoided during mining. It would be useful to be able to predict where salt horses occur. Samples will be collected in areas of salt horses in order to determine if there are any systematic changes in the sylvite ore which could be of use to predict the occurrence of a salt horse. A method of prediction would increase mining efficiency.

### 2.1.4 Fluid Inclusion Studies

The composition of microscopic fluid inclusions that occur within mineral crystals will be determined. The fluid composition will aid in understanding the formation of the deposit. Also, their composition is indicative of the fluids which are involved in the formation of salt horses and caprock.

### 2.1.5 Clay Mineralogy

Thin layers of clay often occur within the ore. The clay can cause problems with mining and ore beneficiation. A study of the clays to characterize them will aid in ore beneficiation and in understanding the geological history of the deposit.

### 2.2.0 Metallurgical Studies

A suite of samples from the mill circuits will be collected. The suite will represent different types of ore (grades, texture and grain size) and/or different operating conditions in the mill. They will be mineralogically and chemically analyzed. Liberation and grain size determination will be made by AIA.

Methods of staining halite and sylvite will have to be developed in order to distinguish them from one another. The difference in optical transmittance between the minerals must be sufficient for AIA.

The results of the mineralogical investigation of the mill samples will be intterpreted by process chemists and metallurgists. Recommendations will be made by these specialists for improvements in the milling circuit if they are required. An additional suite of samples will be collected after recommendations have been implemented in order to monitor the changes.

## PART 2: POTASH COMPANY OF AMERICA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# PART 2: POTASH COMPANY OF AMERICA

## 1.0 SUMMARY

Samples of ore, host rocks and salt horses, and three suites of mill samples were collected by PCA personnel. The composition, mineralogy and petrography of the rock samples was determined. The composition, grain size and liberation of the mill samples was determined. The mineralogy of the clays was examined.

The composition of the ore was variable across the sylvinite bed and no systematic variation was observed. The texture of the ore is a metamorphic texture and can be best described as gneissic. No original textures were observed in hand specimen, and very rarely were they observed microscopicaly, although in the mine large scale bedding features can be observed. The "gneissic" texture probably hinders liberation in that grain boundaries are irregular and breakage across boundaries would result in ore minerals full of inclusions.

The microscopic textures of the salt horses demonstrate that the sylvite was replaced by the halite. The Br content of the salt horses is higher (average 250 ppm) than the bedded salt (less than 200 ppm), which indicates that the salt horses are not a depositional feature. This combined with the mapping of salt horses by the mine geologist demonstrate the they are channelways in the sylvinite bed where the sylvite was replaced by halite.

The minerals identified in the clay rich areas were illite, kaolinite, chlorite, halloysite and K-feldspar. Many of the samples also contained an amorphous material. No expanding clays were identified, however some of the clays do expand as demonstrated by the expansion of clay layers when the samples are exposed to a humid environment. The presence of illite and feldspar suggest that the metamorphic grade of the deposit is lower greenschist. Very little data are available on the kaolinite-illite-muscovite-feldspar system to allow for a more precise interpretation. The amorphous material may be responsible for the sliming problem that occurs intermittently in the mill.

Congolite a boron mineral which has an ideal formula $(Fe,Mg,Mn)_3(B_6O_9)BO_4Cl$ was extensively studied. Its presence is also suggestive of lower greenschist metamorphism.

A procedure was developed whereby the grind required for good liberation could be predicted from the chord length measurement of the grains in polished thin sections of ore samples. For example in 1986, for 90% liberation the grind should have been 355 microns.

Three sets of mill samples were collected; June 1986, August 27, 1987, and August 28, 1987. Liberation studies were preformed with automated image analysis. In all cases three main problems were identified; the grind was too coarse, the coarse grained liberated sylvite was not floating and some of the other liberated sylvite was not floating.

In June 1986, the grind was 90% greater than 1000 microns whereas to achieve 90% liberation the grind should have been -355 microns. Also, much of coarse liberated sylvite ( >1000 microns) reported to the tails. In each size range some liberated sylvite was reporting to the tails. Even the regrind circuit had a grind of 80% greater than 600 microns.

The two sets of mill samples collected in August had different recoveries; August 27 had the better recovery. All of the above problems were present. The main difference was that the grind for the rougher circuit August 27 was 80% greater than 275 microns whereas for August 28 it was 800 microns. For the regrind circuit it was 80% greater than 300 microns for August 27 compared to 500 microns for August 28.

The main recommendation is that the grind should be finer and the grain size distribution be kept as narrow as possible. There should be no particles larger than 1000 microns. Another milling problem identified is the poor flotation of liberated sylvite. Tests should be carried to solve this problem such as using different reagents, changing the conditioning and residence time. Also, the observation was made by the mill personnel that the sylvite that doesn't float has a deep red colour. A preliminary mineralogical examination of the these grains did not detect chemical or physical difference from the

sylvite that floated. A more extensive examination should be carried out.

It has been established that the salt horses are a result of NaCl saturated brines which intruded into the sylvinite unit and replaced the sylvite with halite. There are still several unanswered questions. What is the origin of the NaCl rich brines? When did the replacement occur; during diagenesis, during metamorphism, or during deformation? Is there a method other than mapping of predicting the location of the salt horses? Some of these questions might be answered through fluid inclusion studies and isotope studies.

The metamorphic grade of the deposit is still undefined and the expanding clays have not been identified. Further petrological work is required to solve these problems.

## DEUXIEME PARTIE: COMPAGNIE DE POTASSSE D'AMERIQUE

### 1.0 RESUME

Des échantillons de minerai, de roches hôtes et de "salt horses", ainsi que trois séries d'échantillons de produits d'usine, ont été recueillis par le personnel de la PCA. La composition, la minéralogie et la pétrographie des échantillons de roches ont été déterminées. La composition, la grosseur de grain et la libération des échantillons de produits d'usine ont été déterminées. La minéralogie de l'argile a été examinée.

La composition du minerai variait dans le lit de sylvinite et aucune variation systématique n'a été observée. Le minerai a une texture métamorphique qui peut être qualifiée surtout de gneisssique. Aucune texture originale n'a été observée chez les spécimens macroscopiques; on en a très rarement observé de façon microscopique, bien que des caractéristiques de stratification à grande échelle puissent être observées dans la mine. La texture "gneissique" entrave probablement la libération puisque les contours de grain sont irréguliers et que la rupture des contours entraînerait des intercalations dans le minerai minéral.

Les textures microscopiques des "salt horses" démontrent que la sylvine a été remplacée par le sel gemme. La teneur en Br des "salt horses" est supérieure (en moyenne 250 ppm) à celle du sel stratifié (moins de 200 ppm), ce que indique que les "salt horses" ne sont pas propres à la sédimentation. Combiné à la représentation sur carte des "salt horses" par les géologues de la mine, cela démontre que ce sont des canaux dans le lit de sylvinite où la sylvine a été remplacée par le sel gemme.

Les minéraux identifiés dans les régions riches en argile sont l'illite, la kaolinite, le chlorite, l'halloysite et le feldspath potassique. Bon nombre de ces échantillons contiennent également un matériau amorphe. Aucune argile expansive n'a été identifiée; toutefois, certaines argiles prennent de l'expansion tel qu'il est démontré par l'expansion des couches d'argile lorsque les échantillons sont exposés à un environnement humide. La présence d'illite et de feldspatch suggère que la qualité métamorphique du gisement est du schiste

vert inférieur. Peu de données sont disponibles au sujet du système kaolinite-illite-muscovite-feldspath pour permettre une interprétation plus précise. Le matériau amorphe peut être la cause du problème de surbroyage qui survient de façon intermittente dans l'usine.

Le congolite, un minéral de bore possédant une formulation idéale (Fe, Mg, $Mn)_3(B_6O_9)Bo_4Cl$ a été étudié de façon exhaustive. Sa présence suggère également un métamorphisme de schiste vert inférieur.

Une méthode a été mise au point afin que le broyage nécessaire pour une bonne libération soit prévu à partir de la longueur de la corde des grains scomme point de référence, dans de minces sections polies d'échantillons de minerai. Par example, en 1986, pour 90% de libération, le broyage aurait dû être de 355 microns.

Trois séries d'échantillons de produits d'usine ont été prélevées: en juin 1986, le 27 août 1987 et le 28 août 1987. Des études de liberation ont été effectuées par analyse d'image automatisée. Dans tous les cas, trois principaux problèmes ont été identifiés: le minerai broyé était trop gros, la sylvine libérée à gros grains ne flottait pas et quelques-unes des autres sylvines ne flottaient pas.

En juin 1986, le broyage était de 90% supérieur à 1000 microns, alors que pour atteindre une libération de 90%, le broyage aurait dû être de -355 microns. De plus, la majeure partie de la sylvine à gros grain libérée (>1000 microns) se rapportait aux rejets. Dans chaque catégorie de grosseur, une certaine quantité de sylvine libérée se rapportait aux rejets. Même le circuit de rebroyage avait un taux de broyage de 80% supérieur à 600 microns.

Les déux séries d'échantillons de produits d'usine recueillies en août avaient un rendement différent; celle du 27 août avait un meilleur rendement. Tous les problèmes mentionnées ci-dessus étaient présents. La principale différence est que le broyage du circuit plus brut du 27 août était de 80% supérieur à 275 microns, tandis qu'il était de 800 microns pour le 28 août. Pour le circuit de rebroyage, il était de 80% supérieur à 300 microns pour le 27 août comparativement à 500 microns pour le 28 août.

La principale recommandation préconise que le broyage soit plus fin et que la distribution de la grosseur de grain soit maintenue aussi étroite que possible. Il ne devrait pas y avoir de particules d'une grosseur supérieure à 1000 microns. Un autre problème de broyage identifié est la faible flottation de la sylvine libérée. Des essais devraient être effectués pour résoudre ce problème, tels que l'utilisation de différents réactifs, la modification du temps de conditionnement et de séjour. Le personnel de l'usine a également fait remarquer que la sylvine qui ne flotte pas a une couleur rouge foncé. Un examen minéralogique préliminaire de ces grains n'a révélé aucune différence chimique ou physique par rapport à la sylvine qui flotte. Un examen plus détaillé devrait être entrepris.

Il a été établi que les "salt horses" sont un résultat des saumures saturées du NaCl qui étaient introduites dans l'unité de sylvine et replacées dans la sylvine avec l'halite. Plusieurs questions demeurent toujours sans résponse. D'où proviennent les saumures riches du NaCl? Quand le remplacement a-t-il eu lieu? Pendant le diagnostic, la métamorphose ou la déformation? Y a-t-il une méthode autre que la représentation sur carte pour prédire l'emplacement des "salt horses"? On pourrait probablement répondre à certaines de ces questions par des études d'inclusion fluide et d'isotope.

La qualité métamorphique du gisement n'est toujours pas défini et l'argile expansive n'a pas été identifiée. D'autres travaux pétrologiques sont nécessaire pour résoudre ces problèmes.

## 2.0 INTRODUCTION

Samples of ore and host rocks were collected from the mine and drill core. A sample catalogue is given in Appendix A-1. Three suites of mill samples were collected; a suite was collected in June 1986 before the installation of a regrind mill, and two suites were collected in August 1987. The suite collected on August 27, 1987 was when the mill was operating properly whereas the set collected on August 28 was from a period when the mill was not operating correctly.

The mineralogy, petrography, grain size and chemical composition was determined for the rock samples. The grain size, liberation, mineral mode and chemical composition was determined for the mill samples.

## 3.0 GEOCHEMISTRY OF THE ORE SAMPLES

The chemical composition of the rock samples collected is given in Table 1. The samples analyzed include samples of ore, salt horses, marker beds, halite units, and anhydrite-halite units. The composition of the ore varies from 11 to 33 Wt% K and no systematic changes across the sylvinite bed was observed. It was hoped that there would be a chemical indicator that would help locate salt horses. None was found. The changes from ore to horse is chemically as sharp as the geographic contact. The Br composition of the rocks did lead to an understanding of the genesis of the salt horses and it will be discussed in detail later.

Table 1. Chemical analyses of PCA ore samples. All of the analyses were done in duplicate.

| DESCRIPTION | MARKER | ORE | MARKER | L.G.B. | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5001 | 5002 | 5003 | 5004 | 5005A | 5005B | 5005C | 5006 | 5007 | 5008 | 5009 | 5010 | 5011 | 5012 |
| WT% | | | | | | | | | | | | | | |
| K | 17.86 | 21.47 | .78 | 25.72 | 1.01 | 7.55 | .47 | 22.58 | 14.61 | 26.71 | 22.79 | 17.75 | 20.96 | 25.40 |
| CA | .22 | .31 | .44 | .23 | .40 | .21 | .36 | .13 | .17 | .21 | .20 | .16 | .08 | .07 |
| NA | 25.83 | 20.34 | 36.86 | 19.30 | 36.30 | 32.49 | 36.90 | 17.94 | 28.23 | 19.16 | 21.55 | 24.41 | 21.55 | 18.12 |
| CL | 55.95 | 50.35 | 57.80 | 51.80 | | 56.75 | 57.15 | 56.40 | 56.30 | 52.80 | 52.10 | 53.35 | 52.00 | 51.20 |
| SO4 | .47 | .33 | .99 | .41 | | .46 | .74 | .27 | .34 | .48 | .40 | .32 | .28 | .11 |
| INSOLUBLES | <.50 | 5.38 | 3.17 | 2.25 | | 2.95 | 3.85 | 2.75 | 4.20 | 3.30 | 4.00 | 3.05 | 3.95 | 4.80 |
| PPM | | | | | | | | | | | | | | |
| MG | 30 | 266 | 32 | 48 | 54 | 31 | 15 | 238 | 174 | 320 | 375 | 333 | 243 | 487 |
| FE | 99 | 469 | 62 | 366 | 93 | 176 | 95 | 2011 | 635 | 1248 | 1343 | 967 | 890 | 1157 |
| MN | 7 | 8 | <10 | | | <10 | <10 | 19 | 6 | 6 | 18 | 13 | 13 | 11 |
| ZN | 5 | 10 | 16 | | | <10 | <10 | 23 | 5 | <10 | 7 | 9 | 14 | 14 |
| BR | 900 | 725 | 253 | | | 445 | 180 | 705 | 708 | 749 | 809 | 720 | 758 | 862 |
| SR | <10 | 12 | 9 | | | 11 | 11 | 19 | 13 | 10 | 13 | 11 | <10 | 283 |
| RB | 14 | 13 | <10 | | | 5 | 11 | 18 | 19 | 23 | 13 | 12 | 20 | <10 |
| B | <2 | 6 | <2 | <2 | | 1 | <2 | 32 | 5 | 7 | 7 | 7 | 5 | 7 |
| TOTAL | 100.43 | 98.33 | 100.08 | 99.75 | 37.72 | 100.48 | 99.50 | 100.38 | 104.01 | 102.90 | 101.30 | 99.24 | 99.01 | 99.98 |
| NORM | | | | | | | | | | | | | | |
| SYLVITE K | 34.05 | 40.94 | 1.49 | 49.04 | 1.93 | 14.40 | .90 | 43.05 | 27.86 | 50.93 | 43.45 | 33.84 | 39.96 | 48.43 |
| HALITE NA | 65.66 | 51.71 | 93.70 | 49.06 | 92.28 | 82.59 | 93.80 | 45.60 | 71.76 | 48.71 | 54.78 | 62.05 | 54.78 | 46.06 |
| ANAL. CL | 55.95 | 50.35 | 57.80 | 51.80 | .00 | 56.75 | 57.15 | 56.40 | 56.30 | 52.80 | 52.10 | 53.35 | 52.00 | 51.20 |
| CAL. CL | 56.02 | 50.83 | 57.55 | 53.08 | 56.89 | 56.95 | 57.33 | 48.14 | 56.78 | 53.76 | 53.89 | 53.73 | 52.23 | 50.97 |
| ANHYDRITE | .75 | 1.05 | 1.49 | .78 | 1.36 | .71 | 1.22 | .44 | .58 | .71 | .68 | .54 | .27 | .24 |
| CAL SO4 | .53 | .74 | 1.05 | .55 | .96 | .50 | .86 | .31 | .41 | .50 | .48 | .38 | .19 | .17 |
| INSOLUBLES | .00 | 5.38 | 3.17 | 2.25 | .00 | 2.95 | 3.85 | 2.75 | 4.20 | 3.30 | 4.00 | 3.05 | 3.95 | 4.80 |
| NORM TOTAL | 100.46 | 99.07 | 99.85 | 101.13 | 95.56 | 100.65 | 99.77 | 91.85 | 104.40 | 103.65 | 102.91 | 99.49 | 98.97 | 99.53 |

Table 1. Continued.

| DESCRIPTION | ORE | ORE | MARKER | HALITE | HALITE | HALITE | HALITE | HALITE | BORATE | HALITE | HALITE | AN&HAL | HALITE | HALITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5013 | 5014 | 5015 | 5017 | 5018 | 5019 | 5020 | 5021 | 5022 | 5023 | 5024A | 5024B | 5024C | 5025A |
| WT% | | | | | | | | | | | | | | |
| K | 23.43 | 17.37 | 7.63 | .70 | .75 | .29 | .32 | .23 | .48 | .37 | .31 | .30 | .25 | .20 |
| CA | .19 | .15 | .12 | .24 | .64 | .28 | .27 | .63 | .38 | .31 | .65 | 6.27 | 1.07 | 1.40 |
| NA | 19.23 | 23.93 | 30.85 | 38.06 | 36.56 | 38.21 | 38.19 | 38.24 | 37.10 | 36.97 | 37.40 | 13.32 | 38.10 | 35.53 |
| CL | 53.20 | 52.85 | 52.70 | 57.40 | 57.75 | 56.80 | 57.45 | 58.10 | 57.65 | 56.95 | 58.55 | 19.55 | 59.10 | 56.75 |
| SO4 | .48 | .30 | .32 | .39 | 1.41 | .78 | .56 | 1.40 | .37 | .53 | 2.21 | 24.83 | 3.92 | 6.35 |
| INSOLUBLES | 5.60 | 5.95 | 7.80 | 2.80 | 3.90 | 3.87 | 2.80 | 3.45 | 3.80 | 4.65 | 3.20 | 16.75 | 1.20 | 4.25 |
| PPM | | | | | | | | | | | | | | |
| MG | 212 | 270 | 25 | 25 | 1199 | 31 | 6 | 12 | 486 | 205 | 39 | 11750 | 1086 | 1164 |
| FE | 647 | 772 | 74 | 55 | 982 | 115 | 336 | 57 | 701 | 596 | 20 | 7161 | 375 | 415 |
| MN | <10 | 12 | <10 | <10 | 34 | <10 | <10 | <10 | <10 | <10 | <10 | 303 | 35 | <10 |
| ZN | 7 | <10 | <10 | <10 | 8 | 4 | 6 | 6 | <10 | <10 | <10 | 15 | <10 | <10 |
| BR | 1022 | 732 | 465 | 115 | 70 | 43 | 90 | 60 | 130 | 125 | 5 | 8 | 58 | 43 |
| SR | 5 | <10 | 13 | <10 | 45 | 6 | <10 | <10 | 128 | 25 | 40 | 884 | 139 | 114 |
| RB | 20 | 8 | 10 | 6 | 7 | 4 | <10 | <10 | <10 | <10 | <10 | 17 | 5 | <10 |
| B | 7 | 8 | <2 | <2 | 6 | <2 | <2 | <2 | 1709 | 4 | | 40 | 9 | <2 |
| TOTAL | 101.84 | 100.73 | 99.48 | 99.61 | 101.25 | 100.25 | 99.63 | 102.06 | 100.09 | 99.87 | 102.33 | 83.04 | 103.81 | 104.65 |
| NORM | | | | | | | | | | | | | | |
| SYLVITE K | 44.67 | 33.12 | 14.55 | 1.33 | 1.43 | .55 | .61 | .44 | .92 | .71 | .59 | .57 | .48 | .38 |
| HALITE NA | 48.88 | 60.83 | 78.42 | 96.75 | 92.94 | 97.13 | 97.08 | 97.21 | 94.31 | 93.98 | 95.07 | 33.86 | 96.85 | 90.32 |
| ANAL. CL | 53.20 | 52.85 | 52.70 | 57.40 | 57.75 | 56.80 | 57.45 | 58.10 | 57.65 | 56.95 | 58.55 | 19.55 | 59.10 | 56.75 |
| CAL. CL | 50.90 | 52.65 | 54.49 | 59.32 | 57.06 | 59.18 | 59.18 | 59.18 | 57.64 | 57.34 | 57.95 | 20.81 | 58.98 | 54.97 |
| ANHYDRITE | .65 | .51 | .41 | .82 | 2.17 | .95 | .92 | 2.14 | 1.29 | 1.05 | 2.21 | 21.30 | 3.63 | 4.76 |
| CAL SO4 | .46 | .36 | .29 | .58 | 1.53 | .67 | .65 | 1.51 | .91 | .74 | 1.56 | 15.03 | 2.56 | 3.36 |
| INSOLUBLES | 5.60 | 5.95 | 7.80 | 2.80 | 3.90 | 3.87 | 2.80 | 3.45 | 3.80 | 4.65 | 3.20 | 16.75 | 1.20 | 4.25 |
| NORM TOTAL | 99.80 | 100.41 | 101.18 | 101.70 | 100.44 | 102.51 | 101.41 | 103.24 | 100.32 | 100.39 | 101.07 | 72.48 | 102.16 | 99.71 |

Table 1. Continued.

| DESCRIPTION | HALITE | HALITE | HALITE | ANHY | HALITE | ORE | HALITE | ORE | ORE | ORE | ORE | ORE | ORE | ORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5025B | 5026A | 5026B | 5027A | 5027B | 5028A | 5028B | 5029 | 5030 | 5031 | 5032 | 5033 | 5034 | 5035 |
| WT% | | | | | | | | | | | | | | |
| K | .19 | 3.92 | 10.66 | .59 | .43 | 20.45 | 8.31 | 24.21 | 30.98 | 22.97 | 26.10 | 27.95 | 24.79 | 28.55 |
| CA | .78 | .12 | .15 | 9.29 | .41 | 1.04 | .75 | .46 | .35 | .30 | .63 | .61 | .51 | .48 |
| NA | 37.57 | 35.40 | 30.07 | 11.16 | 36.69 | 22.78 | 31.60 | 22.19 | 15.12 | 21.56 | 19.12 | 18.39 | 21.26 | 18.03 |
| CL | 57.20 | 57.10 | 55.95 | 16.85 | 55.85 | 54.00 | 55.30 | 54.20 | 50.90 | 54.05 | 49.65 | 52.25 | 53.10 | 52.10 |
| SO4 | 2.98 | .28 | .46 | 41.69 | 1.59 | .19 | .49 | .42 | .20 | .10 | .10 | .25 | .22 | .18 |
| INSOLUBLES | 3.55 | 2.65 | 4.10 | 7.55 | 5.55 | .31 | 1.09 | .38 | .18 | .18 | .23 | .10 | .71 | .29 |
| PPM | | | | | | | | | | | | | | |
| MG | 12 | 481 | 369 | 167 | <10 | <10 | 295 | 531 | 26 | 255 | 213 | 387 | 30 | 403 |
| FE | 15 | 440 | 1551 | 505 | 56 | 703 | 786 | 2386 | 748 | 2340 | 1911 | 2093 | 455 | 2188 |
| MN | <10 | <10 | 7 | 7 | 7 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| ZN | <10 | 6 | <10 | 13 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| BR | 10 | 205 | 275 | <10 | 25 | 700 | 285 | 730 | 1310 | 935 | 940 | 1020 | 1400 | 1200 |
| SR | 65 | 33 | 56 | 853 | <10 | 13 | <10 | 8 | <10 | <10 | <10 | <10 | 13 | 18 |
| RB | <10 | <10 | <10 | <10 | <10 | 25 | <10 | <10 | 24 | 27 | 28 | 20 | 17 | 38 |
| B | <2 | 33 | 59 | 1 | <2 | 6 | 6 | 29 | <2 | 5 | 5 | 7 | <2 | 9 |
| TOTAL | 102.28 | 99.59 | 101.62 | 87.28 | 100.52 | 98.91 | 97.67 | 102.22 | 97.93 | 99.51 | 96.13 | 99.90 | 100.78 | 100.02 |
| NORM | | | | | | | | | | | | | | |
| SYLVITE K | .36 | 7.47 | 20.33 | 1.12 | .82 | 38.98 | 15.84 | 46.15 | 59.06 | 43.79 | 49.75 | 53.29 | 47.27 | 54.44 |
| HALITE NA | 95.50 | 89.99 | 76.44 | 28.37 | 93.27 | 57.91 | 80.33 | 56.41 | 38.44 | 54.81 | 48.59 | 46.75 | 54.04 | 45.83 |
| ANAL. CL | 57.20 | 57.10 | 55.95 | 16.85 | 55.85 | 54.00 | 55.30 | 54.20 | 50.90 | 54.05 | 49.65 | 52.25 | 53.10 | 52.10 |
| CAL. CL | 58.11 | 58.14 | 56.03 | 17.74 | 56.97 | 53.66 | 56.26 | 56.16 | 51.40 | 54.07 | 53.14 | 53.70 | 55.26 | 53.69 |
| ANHYDRITE | 2.65 | .41 | .51 | 31.56 | 1.39 | 3.53 | 2.55 | 1.56 | 1.19 | 1.02 | 2.14 | 2.07 | 1.73 | 1.63 |
| CAL SO4 | 1.87 | .29 | .36 | 22.27 | .98 | 2.49 | 1.80 | 1.10 | .84 | .72 | 1.51 | 1.46 | 1.22 | 1.15 |
| INSOLUBLES | 3.55 | 2.65 | 4.10 | 7.55 | 5.55 | .31 | 1.09 | .38 | .18 | .18 | .23 | .10 | .71 | .29 |
| NORM TOTAL | 102.07 | 100.52 | 101.37 | 68.60 | 101.03 | 100.73 | 99.81 | 104.50 | 98.86 | 99.79 | 100.72 | 102.21 | 103.75 | 102.19 |

Table 1. Continued.

| DESCRIPTION | ORE | ORE | ORE | ORE | ORE | HORSE | HORSE | HORSE | HORSE | MARKER | HORSE | 110 C | 60 C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5036 | 5037 | 5038 | 5039 | 5040 | 5042A | 5042B | 5042C | 5042D | 5042E | 5043 | 5049 | 5050 |
| WT% | | | | | | | | | | | | | |
| K | 33.39 | 14.60 | 9.37 | 21.47 | 23.67 | .18 | .35 | .21 | .28 | 7.63 | .20 | 18.19 | 17.70 |
| CA | .74 | .45 | .44 | .39 | .45 | .29 | .28 | .43 | .35 | .12 | .65 | .90 | .89 |
| NA | 14.59 | 27.90 | 31.21 | 21.47 | 22.50 | 35.04 | 38.17 | 34.35 | 36.26 | 30.85 | 36.49 | 15.94 | 15.70 |
| CL | 51.00 | 55.00 | 54.50 | 54.05 | 54.60 | 54.60 | 59.45 | 53.20 | 56.33 | 52.70 | 56.70 | 41.65 | 40.85 |
| SO4 | .20 | .39 | .44 | .23 | .24 | 1.19 | .42 | 1.08 | .63 | .81 | 1.69 | .25 | |
| INSOLUBLES | 1.53 | .61 | .21 | <.05 | <.05 | 7.06 | .93 | 8.29 | <.5 | 7.80 | 4.71 | 5.04 | 4.57 |
| PPM | | | | | | | | | | | | | |
| MG | 349 | 446 | 280 | 601 | 38 | 645 | 153 | 130 | 141 | 1850 | 1076 | 1828 | 1916 |
| FE | 2230 | 91 | 120 | 162 | 30 | 1751 | 166 | 73 | 119 | 3753 | 2823 | 5608 | 5625 |
| MN | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 17 | 13 | <10 | <10 |
| ZN | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 17 | 17 |
| BR | 795 | 685 | 310 | 480 | 825 | 175 | 200 | 250 | 225 | 213 | 183 | | |
| SR | 24 | 23 | 29 | 24 | <10 | 27 | 17 | 26 | 21 | 61 | 50 | 12 | 6 |
| RB | 34 | 17 | <10 | 24 | <10 | 12 | <10 | 15 | 7 | 10 | 16 | <10 | <10 |
| B | 9 | 11 | 8 | <2 | <2 | 5 | 1 | 1 | 7 | 21 | 9 | 10 | |
| TOTAL | 101.78 | 99.07 | 96.24 | 97.74 | 101.54 | 98.62 | 99.65 | 97.61 | 93.90 | 100.50 | 100.85 | 82.72 | 80.47 |
| NORM | | | | | | | | | | | | | |
| SYLVITE K | 63.65 | 27.84 | 17.87 | 40.94 | 45.12 | .34 | .67 | .40 | .53 | 14.55 | .38 | 34.68 | 33.75 |
| HALITE NA | 37.08 | 70.91 | 79.32 | 54.58 | 57.20 | 89.07 | 97.03 | 87.32 | 92.17 | 78.42 | 92.76 | 40.52 | 39.91 |
| ANAL. CL | 51.00 | 55.00 | 54.50 | 54.05 | 54.60 | 54.60 | 59.45 | 53.20 | 56.33 | 52.70 | 56.70 | 41.65 | 40.85 |
| CAL. CL | 52.76 | 56.25 | 56.61 | 52.57 | 56.15 | 54.20 | 59.18 | 53.16 | 56.17 | 54.49 | 56.45 | 41.07 | 40.26 |
| ANHYDRITE | 2.51 | 1.53 | 1.49 | 1.32 | 1.53 | .99 | .95 | 1.46 | 1.19 | .41 | 2.21 | 3.06 | 3.02 |
| CAL SO4 | 1.77 | 1.08 | 1.05 | .93 | 1.08 | .70 | .67 | 1.03 | .84 | .29 | 1.56 | 2.16 | 2.13 |
| INSOLUBLES | 1.53 | .61 | .21 | .00 | .00 | 7.06 | .93 | 8.29 | .00 | 7.80 | 4.71 | 5.04 | 4.57 |
| NORM TOTAL | 104.77 | 100.89 | 98.89 | 96.84 | 103.85 | 97.46 | 99.58 | 97.47 | 93.90 | 101.18 | 100.06 | 83.30 | 81.25 |

# 4.0 MINERALOGY OF THE ORE SAMPLES

## 4.1 Sylvite and Halite; Texture and Grain Size

Polished thin sections of ore were examined with the petrographic microscope and the electron microprobe using the back scattered electron image. The halite and sylvite are usually completely recrystallized and deformed. The only primary textures observed are the relict hopper crystals which are evident by the "hopper" type distribution of fluid inclusions, and fine-grained distribution of minute anhydrite crystals into discontinuous layers included in sylvite and halite crystals. Negative crystal fluid inclusions are abundant. The texture is considered metamorphic and is best described as gneissic. Other accessory minerals are anhydrite, clays (which will be discussed in Section 4.2), Fe oxides, pyrite, and carbonates. Figure 1 is a backscattered electron of the typical texture of sylvinite.

The highly irregular grain boundaries will probably cause a problem in achieving good liberation. The rock is more likely to fracture along crystal cleavage planes than along grain boundaries, thereby causing the inclusion of small sized particles in mineral grains. That is, some sylvite will be lost to halite which goes to tailings and halite will be included in sylvite and go to the concentrate.

The size distribution of the sylvite was determined by the chord length measurement as discussed earlier. The results are given in Figure 2. The grain size varies from 4000 microns to 40 microns. For 90% liberation the optimum grind is predicted as 270 microns.

## 4.2 Clay Minerals

The areas of clay usually contain quartz, illite, muscovite, kaolinite, Fe-chlorite and a K-feldspar in addition to halite, sylvite and anhydrite (Table 2). The identification of the minerals was confirmed by qualitative microprobe analysis.

The presence of this assemblage of minerals is suggestive of a lower greenschist metamorphic grade, however a more precise constraint is not possible because the stability fields for this assemblage of clay minerals have not been delineated (Brindley and Brown, 1980 and Srodon, 1984). The K-feldspar is suggestive of higher metamorphism, however diagenetic feldspar has been documented by Walker et al 1978.

No expanding clays were found, however the clay rich layers in the evaporite sequence do expand when exposed to humid conditions. For example, when a polished block of sylvinite which contains a clay rich layer was left exposed to the atmosphere for serval weeks during a period of high humidity, the clay rich layers protruded out from the surface. It might be possible that the anhydrite, which occurs in most clay layers, is hydrated to gypsum which would cause the expansion. Gypsum was found in only one sample, however an amorphous phase was found in several samples. When examined with the electron microscope the material was composed of Ca and S and is probably a hydrated amorphous $CaSO_4$. More work is required to establish with certainty the cause of the expanding layers.

## 4.3 Boron Minerals

The boron minerals were studied in detail by Peter Burns, a student at UNB, as an undergraduate thesis project (Burns 1988). The microprobe analyses were performed at RPC, and the XRD analyses and interpretation were made at UNB. The boron mineral was extracted from Sample No. 5113, Upper Halite. The mineral was identified as Mg-congolite (the type specimen contains only 0.24 Wt% Mg) with a bulk composition of $Mg_{1.47}Fe_{1.27}Mn_{0.03}Ca_{0.02}[B_6O_9]BO_4Cl_{0.94}$, and they are rohombohedral, space group R3c. Mg, Mn and Fe zoning occur in all samples.

Although, no published stability data were available for this composition, the upper stability temperature for rhombohedral end member congolite is $247^0$ C. Again, this suggests a lower greenschist metamorphic grade.

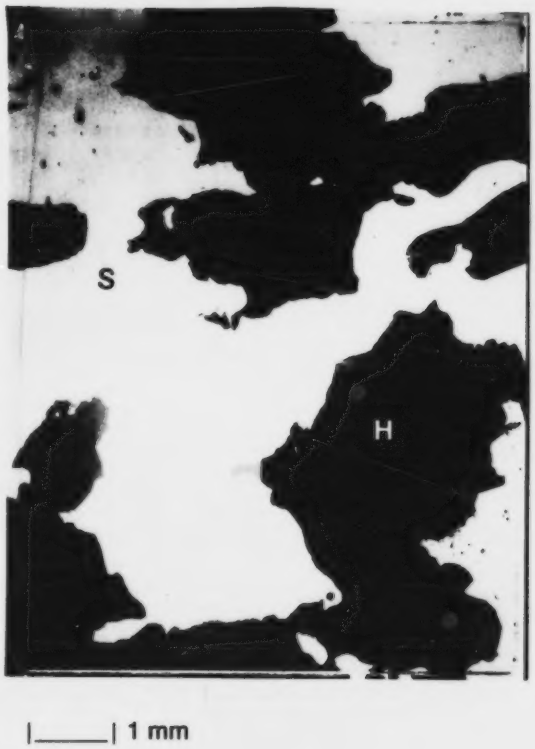



**FIGURE 1** Typical texture of potash ore. Halite (H) and Sylvite (S).

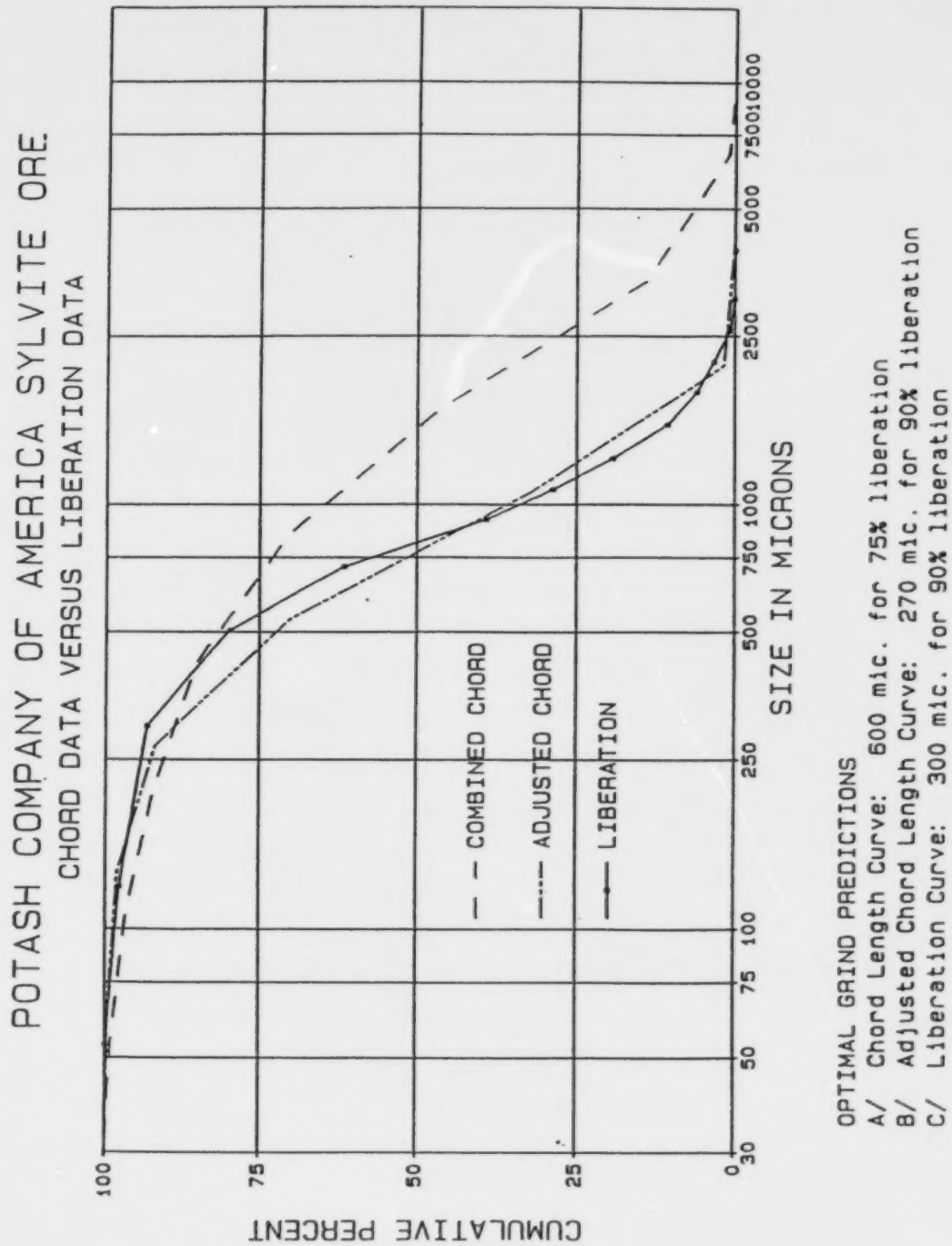



**FIGURE 2** Comparison of the cumulative liberation curve of the rougher concentrate and the cumulative chord length measurements for an unbroken ore sample.

**TABLE 2**

The clay and associated minerals of samples collected from the PCA mine.

| Sample No. | Minerals |
|---|---|
| 5039 Ore | Anhydrite, Halite, Sylvite, Quartz, Muscovite, Microcline |
| 5045 Salt Horse | Anhydrite, Halite, Muscovite, Quartz, Pyrite? |
| 5049 Slime Circuit | Muscovite, Kaolinite, Hematite, Quartz, Bassanite, Ankerite?, Calcite, Halite, Sylvite, Anhydrite, Amorphous |
| 5075 Ore | Sylvite, Halite Anhydrite, Quartz, Muscovite, Sanidine |
| 5081 Ore | Halite, Sylvite, Quartz, Anhydrite, Muscovite, Microcline? |
| 5085 Ore | Muscovite, Halite, Quartz?, Sanidine? |
| 5094D Slime Circuit | Sylvite, Quartz, Halite, Anhydrite, Kaolinite (Disordered), Na-illite, Fe-chlorite |
| 5094K Slime Circuit | Sylvite, Halite, Quartz, Anhydrite, Na-illite, Kaolinite (Disordered), Chlorite |
| 5113 Upper Halite | Quartz, Na-illite, K-feldspar, Halite, Kaolinite (Disordered), Fe-chlorite, Dolomite, Congolite, Sylvite |
| 5114 Middle Halite | Quartz, Anhydrite, K-feldspar, Na-illite, Halite, Kaolinite (Disordered), Gypsum (Formed by HCl Treatment), Fe-chlorite, Sylvite |

**TABLE 2 (cont'd)**

| | |
|---|---|
| 5139 Thickeners u/f<br>Aug. 27, 1987 | Na-muscovite, Fe-chlorite, Halloysite, Kaolinite, Anhydrite, Sylvite, Amorphous Phase |
| 5192 Thickeners u/f<br>Aug. 28, 1987 | Fe-chlorite, Na-muscovite, Halloysite, Kaolinite, Anhydrite, Sylvite, Amorphous Phase |
| 5212 Upper Halite | Anhydrite, Quartz, High Sanidine, Sylvite, Halite, Na-muscovite, Kaolinite, Fe-chlorite, Calcite |
| 5213 H. W. Salt Horse | Halite, Quartz, K-feldspar, Na-muscovite, Kaolinite, Illite |
| 5214 Clay Seam Contact | Quartz, K-feldspar, Halite, Sylvite, Na-muscovite, Illite, Kaolinite, Fe-chlorite, Amorphous Phase |
| 5215 Clay Seam Contact | Quartz, Halite, Na-muscovite, Illite, Kaolinite, Fe-chlorite |
| 5216 Salt Horse Contact | Quartz, K-feldspar, Halite, Sylvite, Na-muscovite, Illite, Kaolinite, Fe-chlorite, Amorphous Phase |
| 5217 Salt Horse | Quartz, K-feldspar, Sylvite, Halite, Na-muscovite, Kaolinite, Illite, Fe-chlorite |
| 5218 Salt Horse | Halite, Sylvite, Quartz, K-feldspar, K-muscovite, Kaolinite, Fe-chlorite, Illite, Amorphous Material |
| 5219 Salt Horse | Quartz, K-feldspar, Halite, Sylvite, Na-muscovite, Kaolinite, Fe-chlorite, Illite, Amorphous Phase |

**TABLE 2 (cont'd)**

| | |
|---|---|
| 5220 Halite | Quartz, K-feldspar, Halite, Na-muscovite, Kaolinite, Fe-chlorite, Illite, Amorphous Phase |
| 5221 Basal Halite | Quartz, Halite, Na-muscovite, Kaolinite, Fe-chlorite, Illite |

## 5.0 SALT HORSES

Salt horses or barren zones are areas within the potash ore that are predominately halite. The salt horses vary in size, location and extent. Underground mapping carried out by the mines has indicated that they are formed by a replacement mechanism after the deposition of the sylvinite beds. From a mining point of view, it is important to be able to predict and map these areas. Therefore, a knowledge of the genesis of the salt horses would greatly aid in this endeavour. PCA and Denison Potocan have agreed to combined the data for this study. A preliminary report was given at the 1988 Current Research Session at the annual meeting of the Atlantic Geoscience Society (Stirling et al 1988).

During the project samples of ore, host rocks and salt horses were collected by the mine geologist. The samples were chemically analyzed, examined petrographically and six samples were selected for microprobe analyses of halite and sylvite.

The concentration of the Br in the ore increases with K to maximum of 1200 ppm, in the stratigraphic halite it is less than 200 ppm, and in the barren zones it is between 200 and 300 ppm (Figure 3). This indicates that the same processes did not form the stratigraphic halite and the salt horses.

After the whole rock data were compiled, the Br content of sylvite and halite minerals was determined by electron microprobe analysis. The results are given graphically for individual samples in Figure 4, Figure 5 is the average for each rock type and the original data is given in Appendix A-2.

The concentration of Br in the halite from the stratigraphic halite Sample 5023 Figure 4a is the lowest , <200 ppm as would be expected from the whole rock data. The concentration of Br halite from the ore varies from not detected to 700 ppm (Figures 4 b, d and e) and from salt horses up to 500 ppm (Figures 4 c and f). The concentration of Br in the sylvite varies from 500 to 4000 ppm (Figures 4 b, c, d, e and f).

The large variation in the Br concentration for sylvite and halite in the sylvinite is probably a reflection of the changing concentration of the Br concentration in the original brine as crystallization proceeded. For example as the brine became more concentrated the amount of Br partitioned to halite (Herrmann 1980) and sylvite would increase (Stoessell and Carpenter 1986). Also the brine composition could change by an influx of fresh water (Stirling et al 1983).

The sylvinite beds should be considered as accumulates in that the salt crystals can form on the brine surface and when they reach a certain size they sink to the bottom. Therefore, the accumulated crystals did not necessarily form in the same chemical environment.

Texturally the halite replaces the sylvite (Figures 6 to 9). The sylvite is interstitial to halite, usually has embayment cusps and narrow spines into the halite. Often the clay minerals are between larger halite grains as though the halite, as it crystallized, pushed the clays to the grain boundaries. The salt horses usually have more fluid inclusions than the other units.

It is speculated that after the diagenesis of the evaporate sequence, a NaCl saturated brine intruded the sylvinite bed dissolving sylvite (thereby increasing the Br concentration of the brine) and precipitating halite which has a higher Br concentration than the stratigraphic halite. The origin of the brine is uncertain. A similar model for barren halite zones at Carlsbad was developed by Linn and Adams (1961), and at Esterhazy by Mcintosh and Wardlaw (1968).

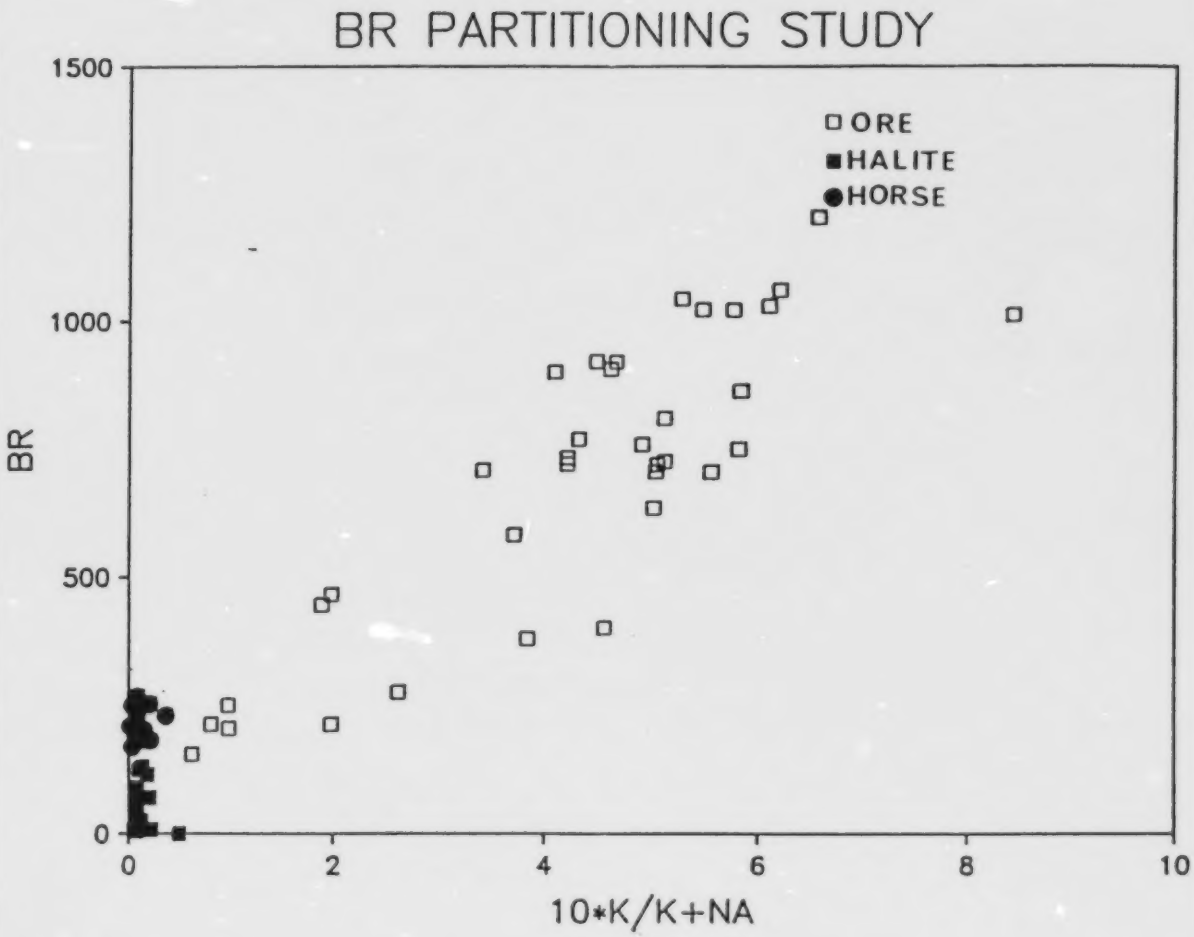



**FIGURE 3** Br content of salt horses as compared to stratigraphic halite and potash ore.

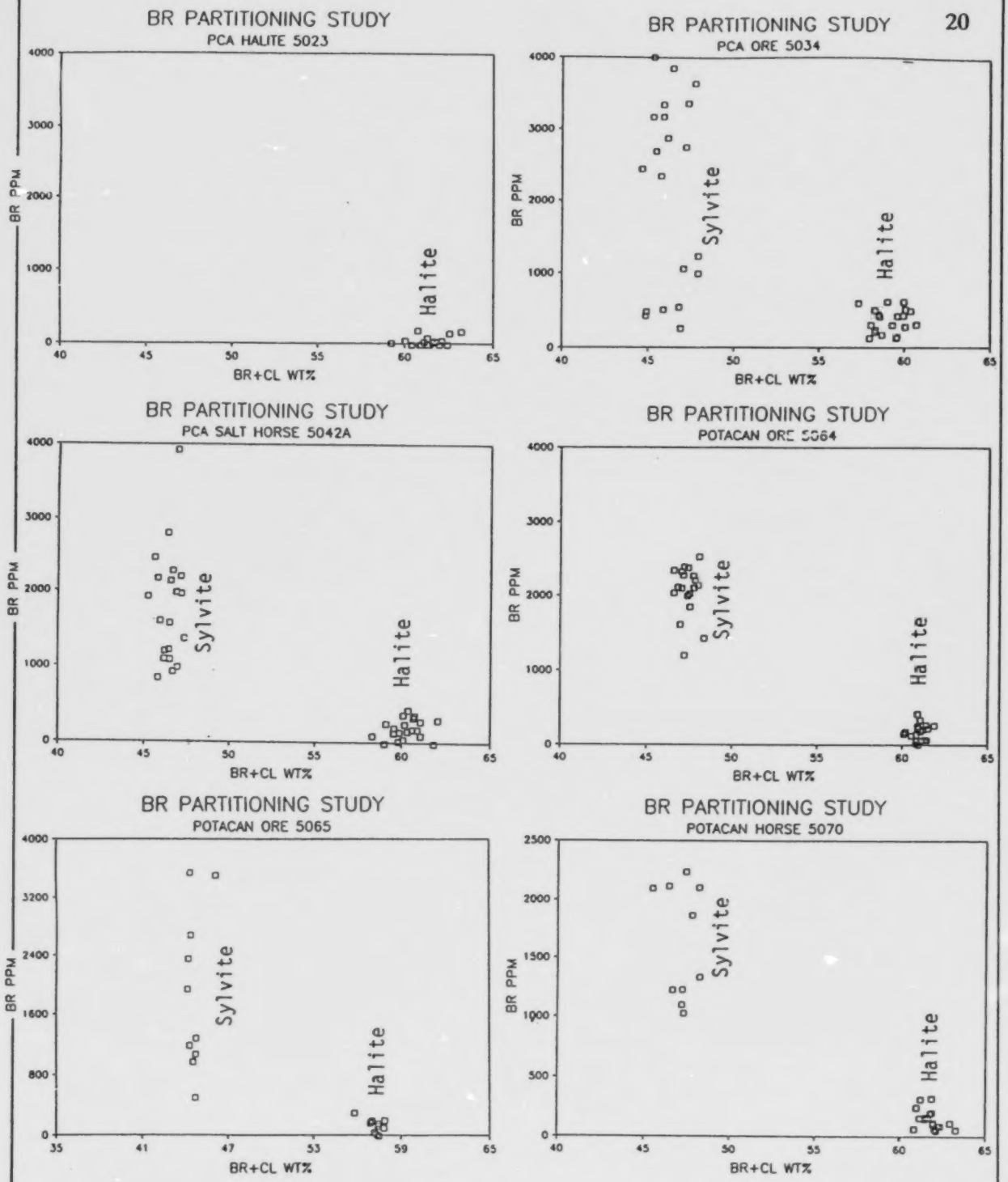



**FIGURE 4** Br content in sylvite and halite for each sample.

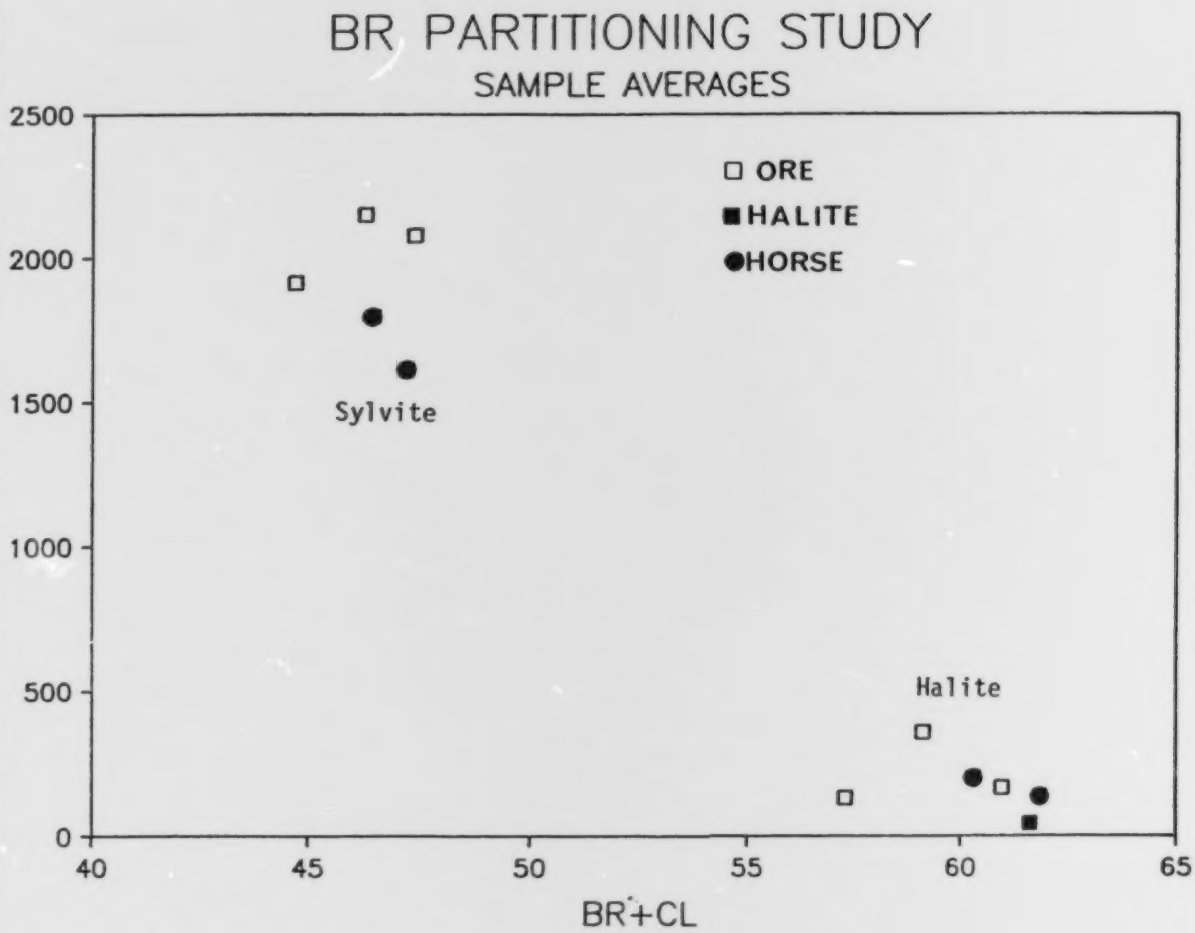



**FIGURE 5** Average Br content for halite and sylvite for each rock type.

**FIGURE 6** Replacement of sylvite (S) by halite (H). Salt horse sample from PCA, RPC #5042.

**FIGURE 7** Remnant sylvite (S) grain in halite (H). The embagment cusps are typical replacement textures. Salt horse sample from PCA, RPC #5042. The white bar equals 1 mm.

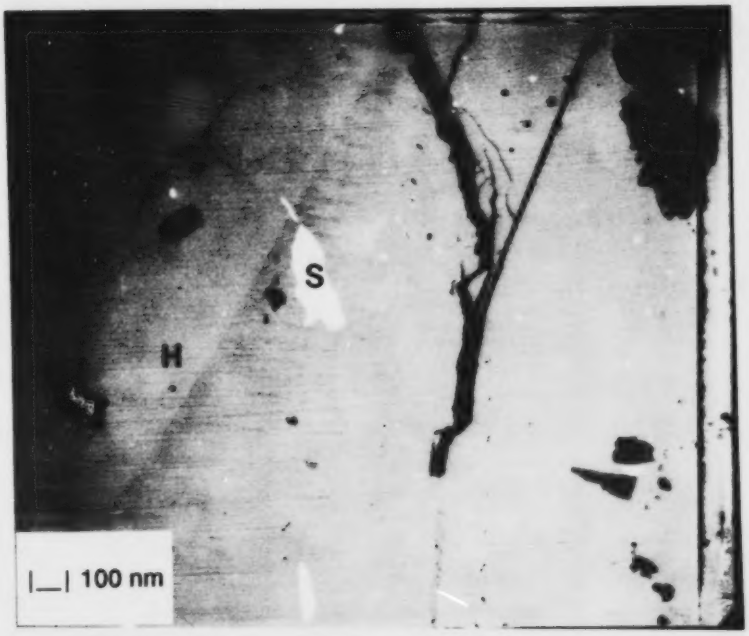



**FIGURE 8** Barren halite (H) zone with anhydrite (A) and remnant sylvite (S) in halite. The white bar equals 100 microns.

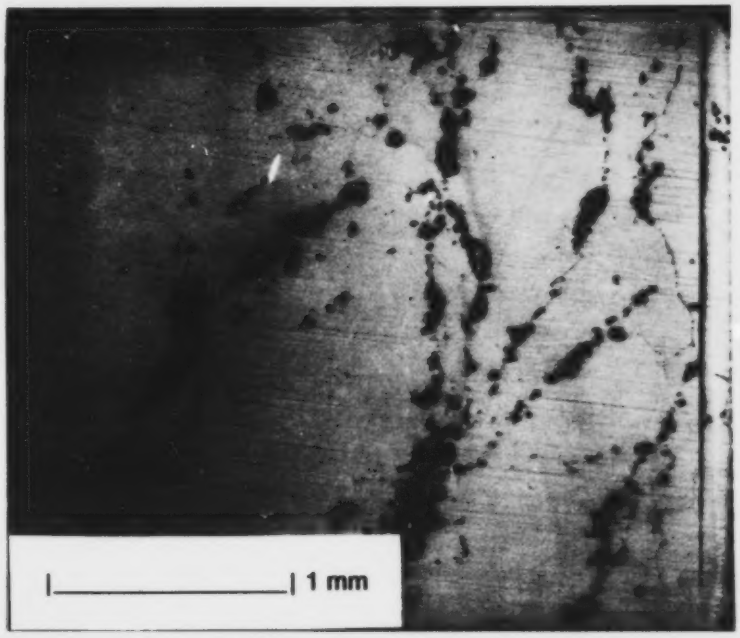



**FIGURE 9** Concentration and alignment of clay minerals about composite halite grains. Black areas are clays, dark area is halite and the white areas are Fe oxides. The white bar equals 1 mm.

## 6.0 EVALUATION OF THE PCA CONCENTRATOR

Three suites of mill samples were collected form the mill at PCA. The first was collected in June 1986 before the installation of a regrind mill. The other two suites were collected on August 27, and August 28, 1987. The first set collected in August was when the mill was operating efficiently and the second was collected when recoveries were low. A list of the samples collected is given in Table 3 and the flow sheet is given in Appendix A-3.

### 6.1 Samples Collected June 1986

The composition for all of the samples was determined and the normative sylvite calculated Appendix A-4. The mass balance for the mill is given in Table 4. The sieve analysis, modal mineralogy and liberation data are given in Appendix A-5.

The liberation curves and the weighted modal mineralogy for the rougher circuit is given in Figure 10. In Figure 10 A, the d80 for the rougher feed is slightly over 1000 microns, however to achieve 86% liberation the grind should be approximately 300 microns. The coarseness of the grind has resulted in poor liberation for coarse material. For example at 1000 microns only 6.0 % of the 17.0% sylvite available is liberated (Figure 11).

In addition to the poor liberation the coarse liberated sylvite is not floating and is reporting to the tails. For example at 1000 microns 3.0% of the liberated sylvite is in the concentrate whereas 4.0% is in the tails Figure 11.

The liberation curves and the weighted modal mineralogy for the screen oversize, undersize, reground tails, and mixed tails are given in Figure 12. The weighted liberation curves are given in Figure 13. Again the grind is too course and liberated sylvite is reporting to the tails. For example at 1000 microns 0.8% of the liberated sylvite is in the mixed tailings, approximately 1.5% is in the screen undersize.

## TABLE 3

### PCA mill samples

**Samples collected in 1986 before the installation of a regrind circuit.**

| Sample No. | Description |
|---|---|
| 5093 | Coarse Concentrate, Surge Tank |
| 5094 | Slimes Centrifuge Effluent |
| 5095 | Slimes Centrifuge Cake |
| 5096 | Slimes Thickener Feed |
| 5097 | Reground Rougher Tails |
| 5098 | Mixed Tailing |
| 5099 | Rougher Flotation Feed |
| 5100 | Rougher Tails Screen Oversize |
| 5101 | Rougher Flotation Concentrate |
| 5102 | Rougher Flotation Tails |
| 5103 | Slimes Centrifuge |
| 5104 | Final Tails |

Samples collected on August 27, 1987 when recoveries were good.

| | |
|---|---|
| 5131 | Mill Product |
| 5132 | Rougher Flotation Feed |
| 5133 | Rougher Flotation Tails |
| 5134 | Rougher Flotation Concentrate |
| 5135 | Ball Mill Feed |
| 5136 | Ball Mill Discharge |
| 5137 | Regrind Flotation Concentrate |
| 5138 | Regrind Flotation Tails |
| 5139 | Slimes Thickener |

Samples collected on August 28, 1987 when recoveries were low.

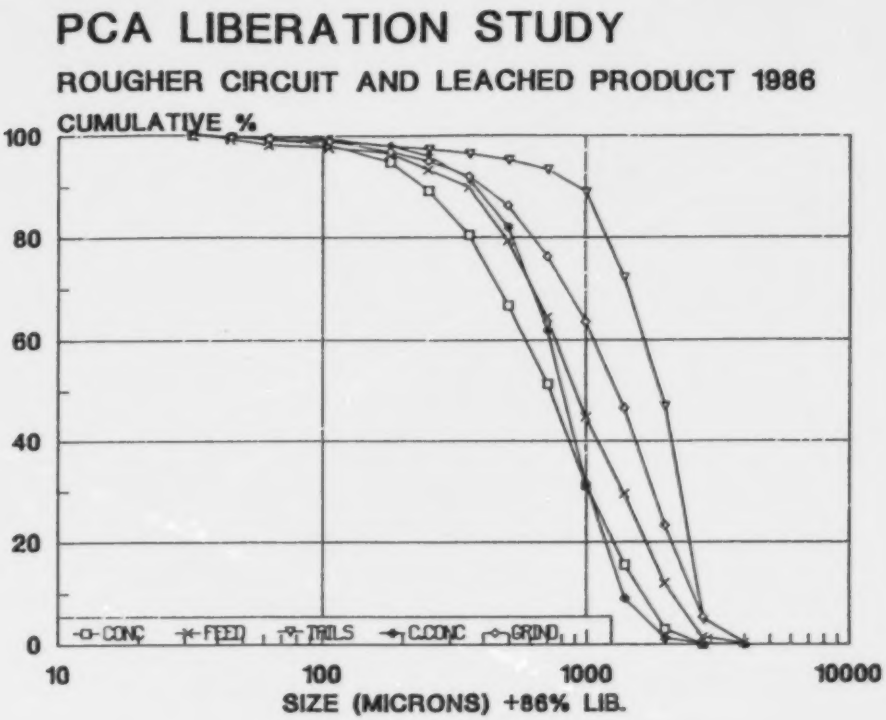
| | |
|---|---|
| 5140 | Regrind Flotation Concentrate |
| 5141 | Rougher Flotation Tails |
| 5142 | Regrind Flotation Tails |
| 5143 | Ball Mill Discharge |
| 5144 | Rougher Flotation Feed |
| 5145 | Ball Mill Feed |
| 5146 | Rougher Flotation Concentrate |

## TABLE 4

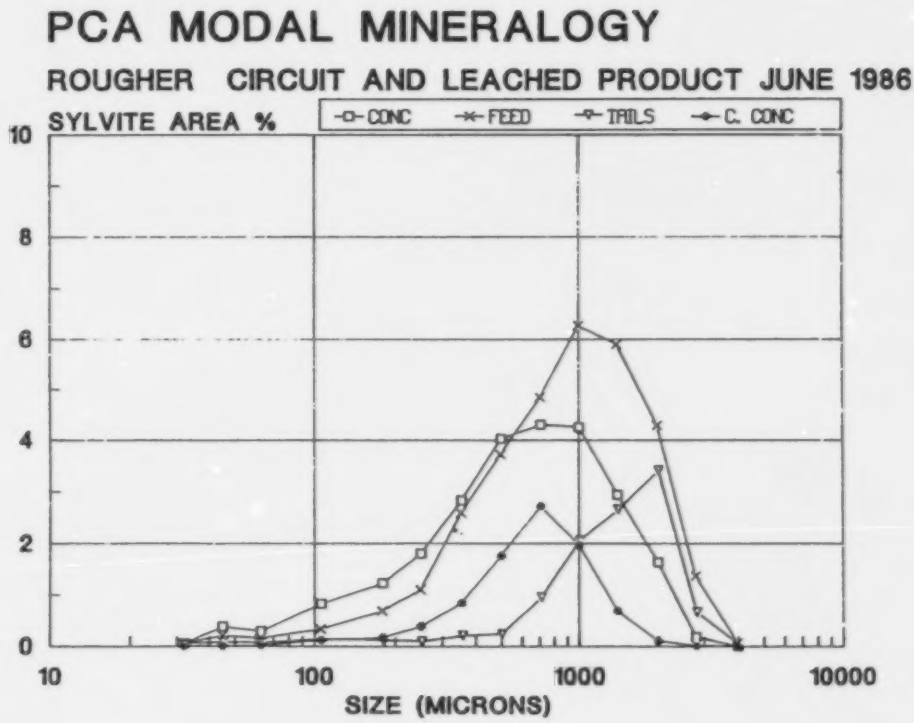
**Estimated Weight Percentage of Collected Streams as Part of the Plant Mass Balance**

**Based on Rougher Flotation Feed - 100%**

| | % Weight |
|---|---|
| Rougher flotation feed | 100 |
| Rougher concentrate | 30 |
| Rougher tails | 70 |
| Rougher tails screen oversize | 35 |
| Rougher tails screen undersize (final tails) | 35 |
| Reground rougher tails | 35 |
| Coarse concentrate slurry tank (leached product) | 9 |
| Slimes thickener feed | 8 |
| Feed to slimes centrifuge | 8 |
| Slimes centrifuge cake | 6 |
| Slimes centrifuge effluent | 2 |
| Mixed tails | 37 |




A




B

**FIGURE 10** Liberation curves (A) and weighted modal mineralogy (B) of the rougher circuit and the leached product. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance. June 1986.

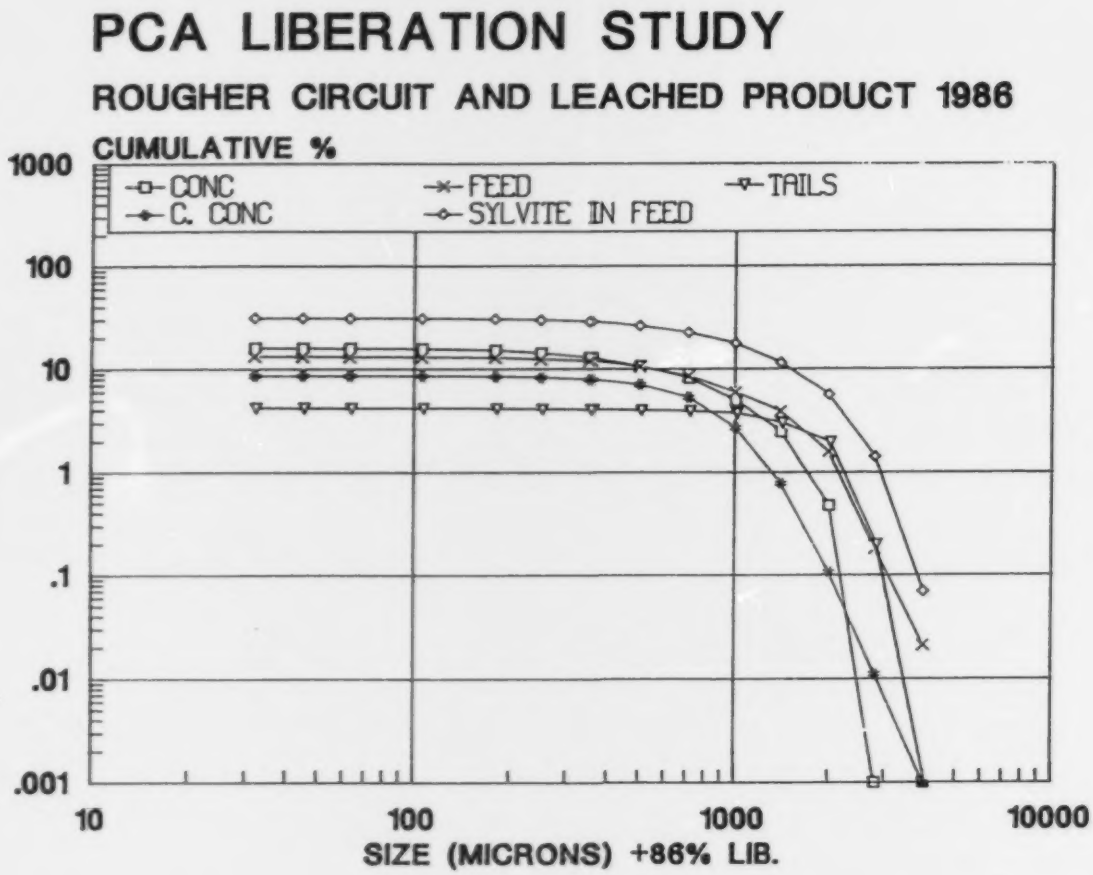
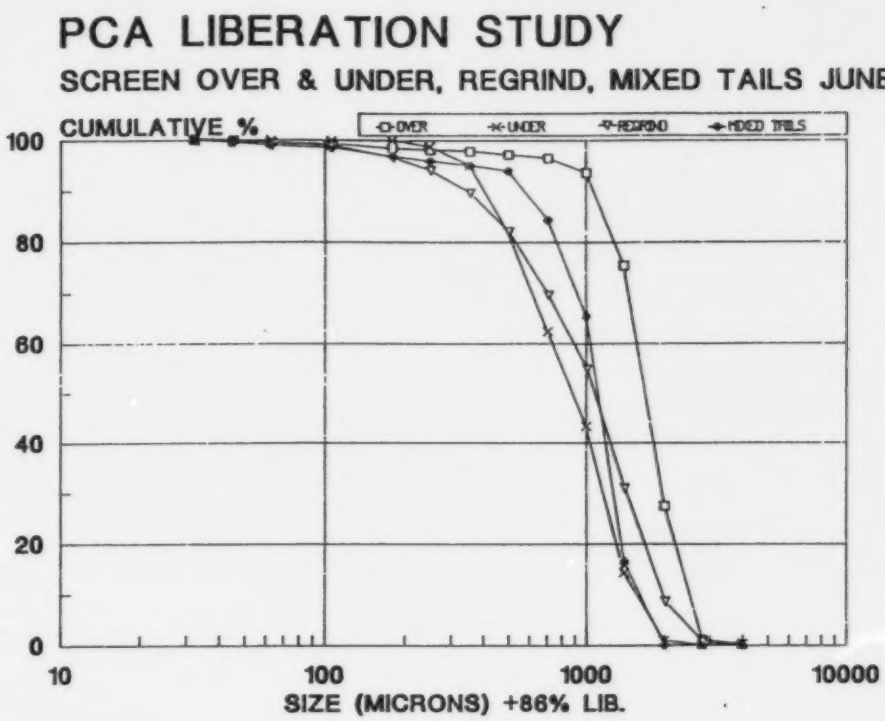
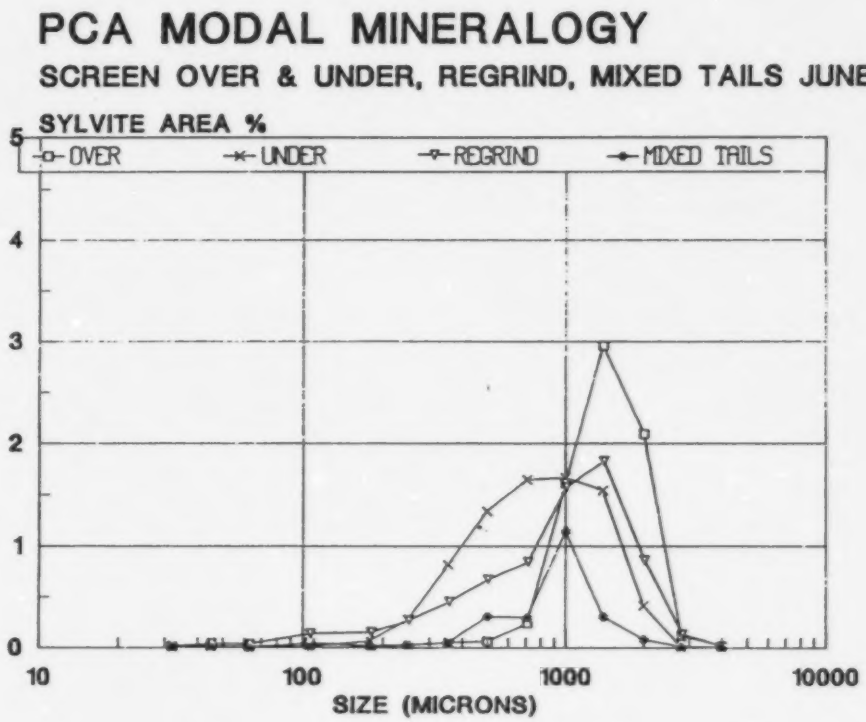



FIGURE 11 Weighted liberation curves for the rougher circuit and the leached product. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite. June 1986.




A




B

**FIGURE 12** Liberation curves (A) and weighted modal mineralogy (B) for the screen oversize and undersize, reground tails and mixed tails. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance. June 1986.

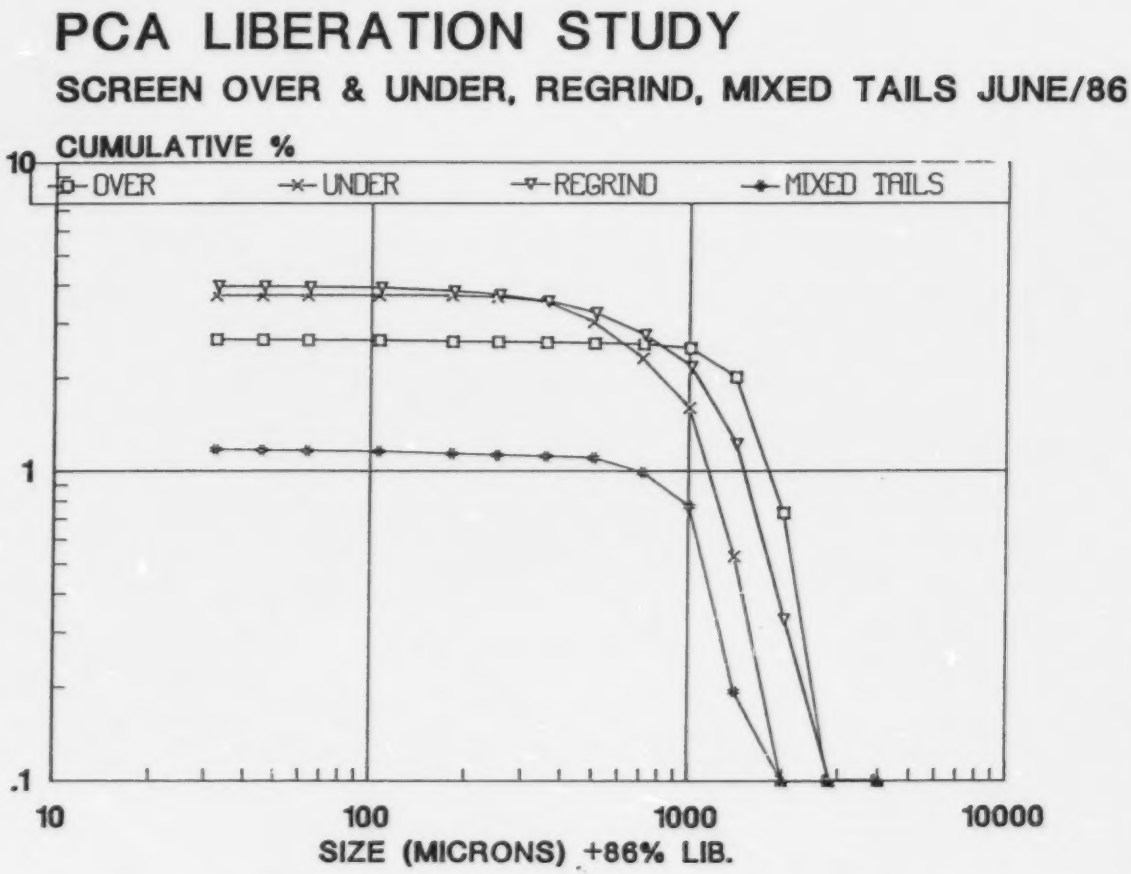



**FIGURE 13** Weighted liberation curves for the screen oversize and undersize, reground tails and mixed tails. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite. June 1986.

## 6.2 Samples Collected August 27 and 28 1987

The composition for all of the samples was determined and the normative sylvite calculated Appendix A-6. The mass balance for the mill is given in Table 5. The sieve analysis, modal mineralogy and liberation data are given in Appendix A-7.

The major difference between the two suites is that the grind for August 27 was much better than that for August 28. The d80 for the rougher circuit for August 27 was 225 microns (Figure 14) whereas for August 28 it was 700 microns (Figure 15). The d80 for the regrind circuits was 400 and 500 microns respectively (Figures 16 and 17).

On both days neither the rougher nor the regrind circuits were floating all of the coarse liberated sylvite (Figures 14, 15, 18 and 19). For example on August 27 material coarser than 1000 microns in the rougher tails contained 2.0% of the liberated sylvite (Figure 20), and in the regrind tails it was 1.0% (Figure 21). On August 28 the tails contained 5.0% (Figure 22) and 2.0% (Figure 23).

**TABLE 5**

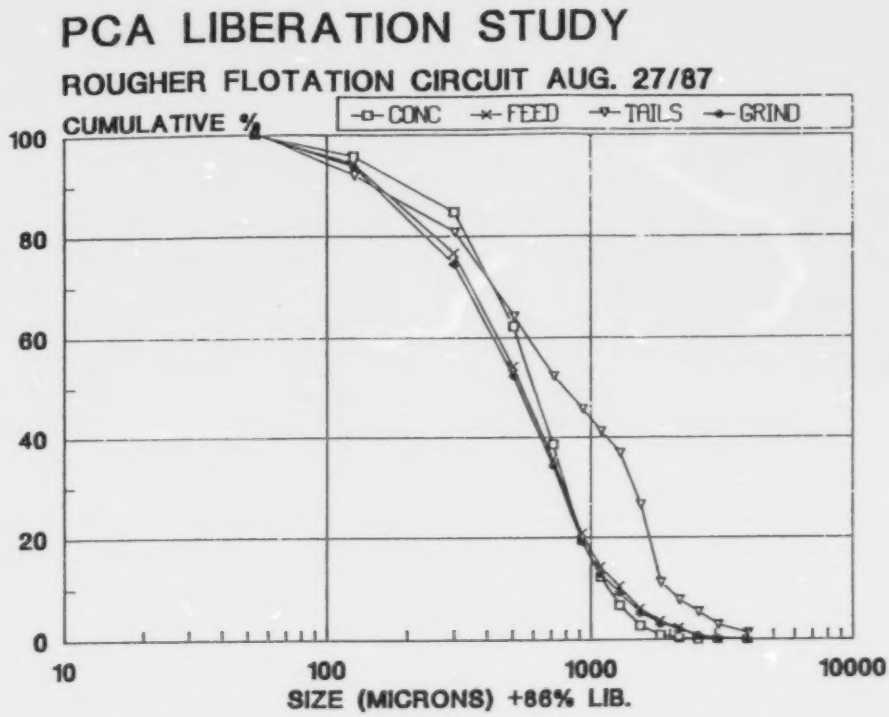
Mill balance for samples collected August 27 and 28

**August 27, 1987**

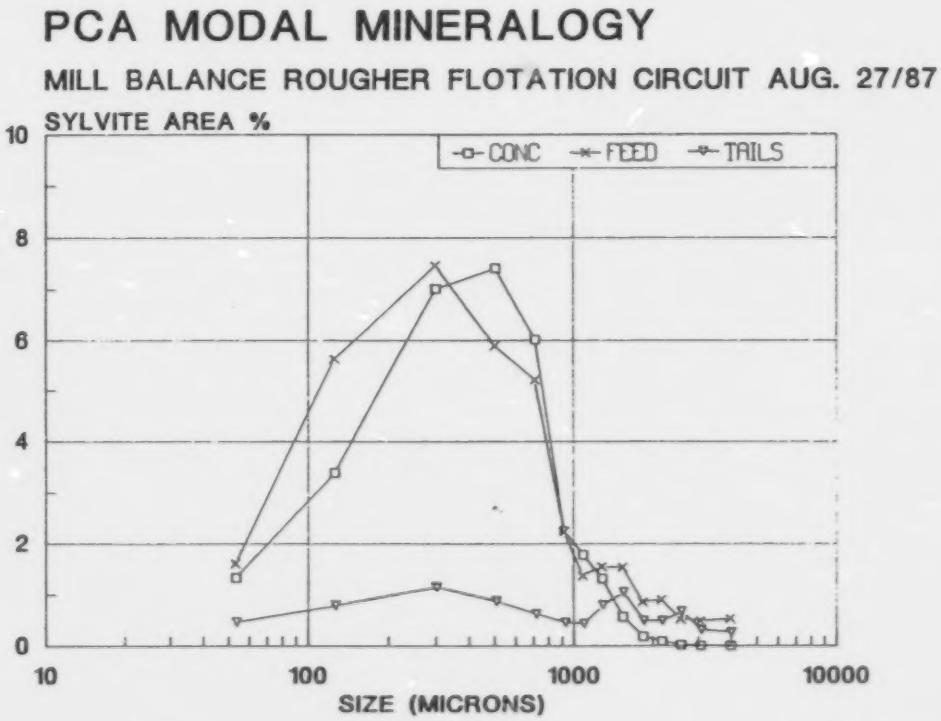
| | |
|---|---|
| Rougher Feed | 100% |
| Rougher Concentrate | 36% |
| Rougher Tail | 64% |
| | |
| Regrind Feed | 42% |
| Regrind Concentrate | 6% |
| Regrind Tail | 36% |

**August 28, 1987**

| | |
|---|---|
| Rougher Feed | 100% |
| Rougher Concentrate | 29% |
| Rougher Tail | 72% |
| | |
| Regrind Feed | 46% |
| Regrind Concentrate | 7% |
| Regrind Tail | 39% |

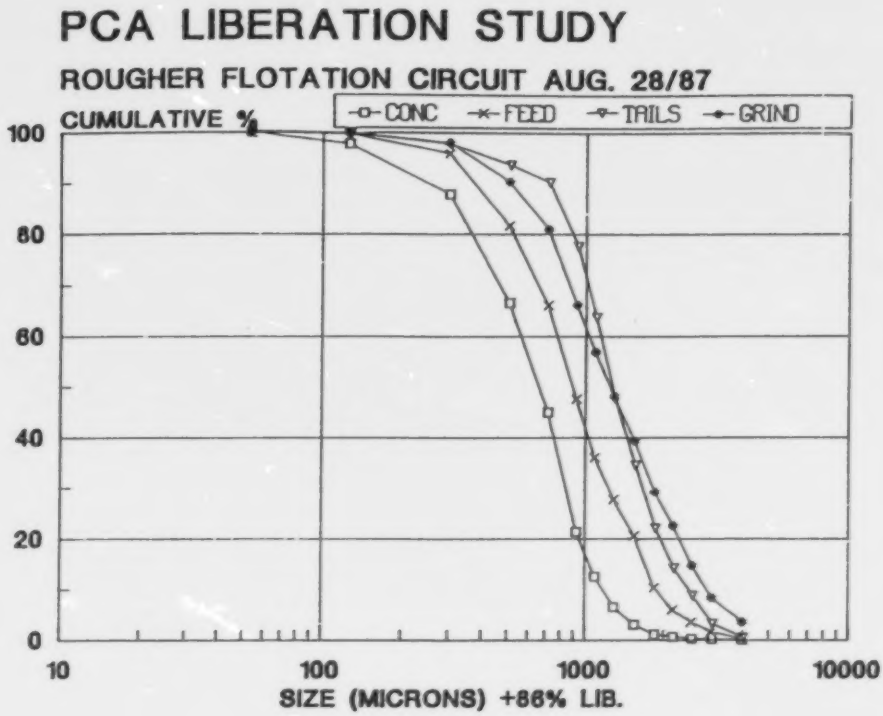



A

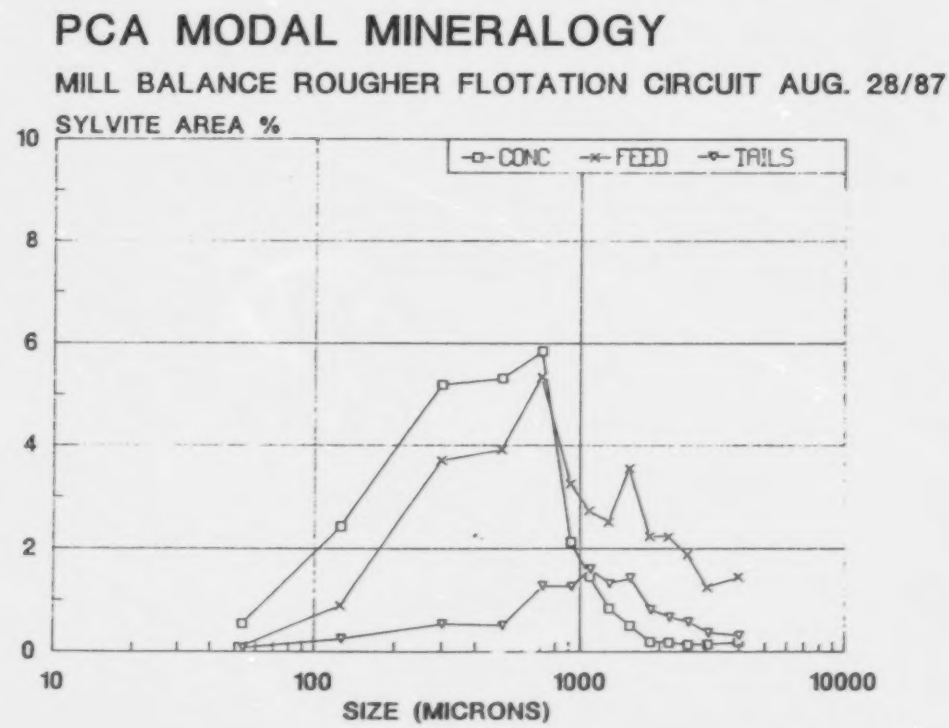



B

**FIGURE 14** Liberation curves (A) and weighted modal mineralogy (B) for the rougher flotation circuit, August 27. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

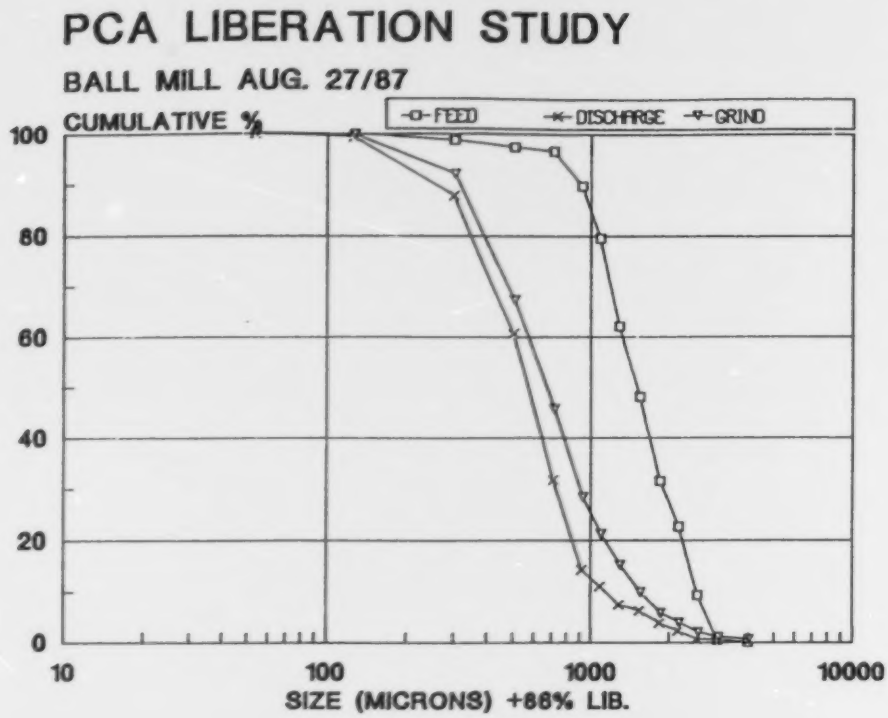



A

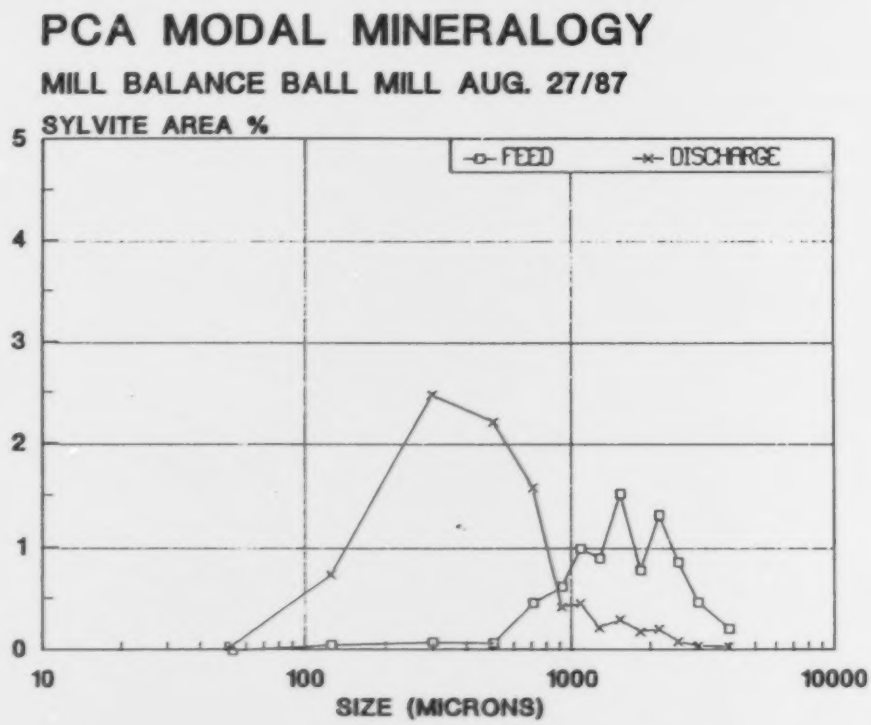



B

**FIGURE 15** Liberation curves (A) and weighted modal mineralogy (B) for the rougher flotation circuit, August 28. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

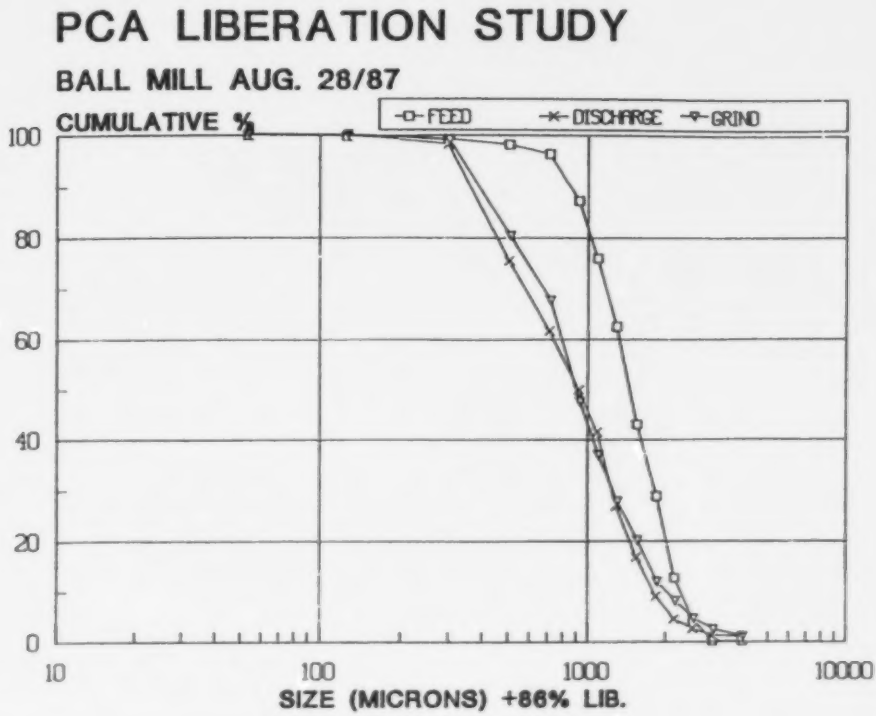



A

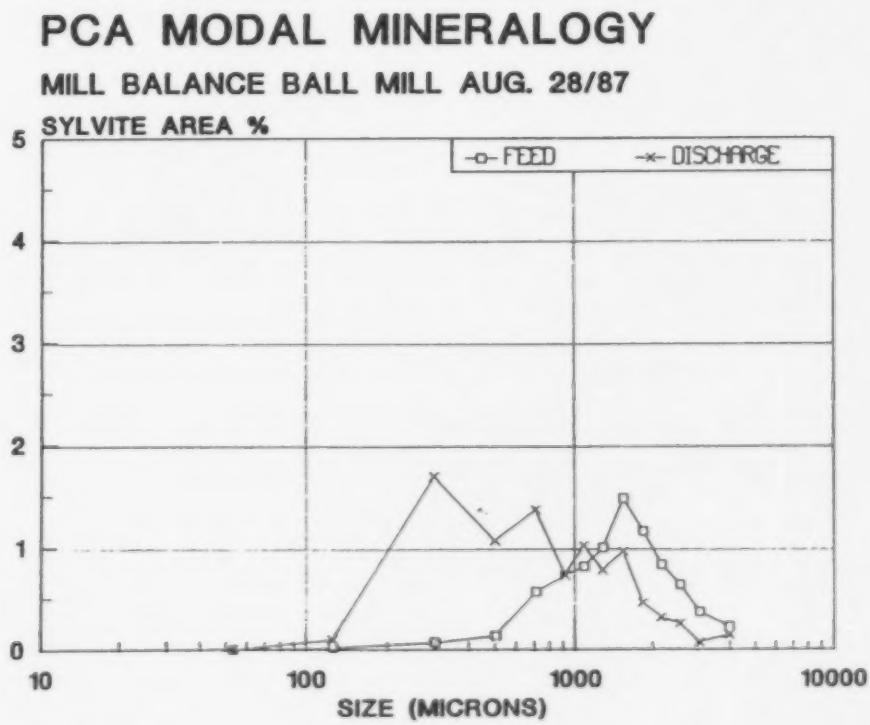



B

**FIGURE 16** Liberation curves (A) and weighted modal mineralogy (B) for the ball mill circuit, August 27. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.




A

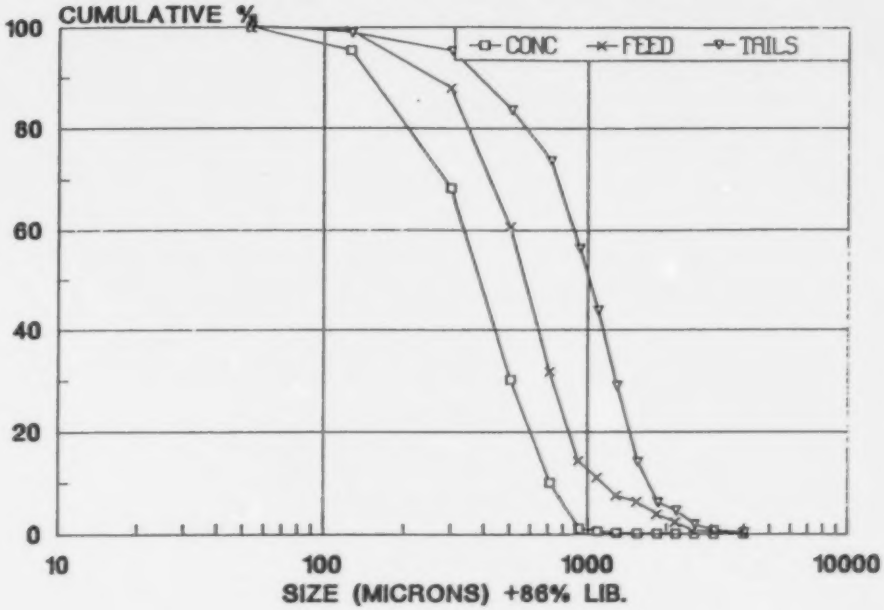



B

FIGURE 17 Liberation curves (A) and weighted modal mineralogy (B) for the ball mill circuit, August 28. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

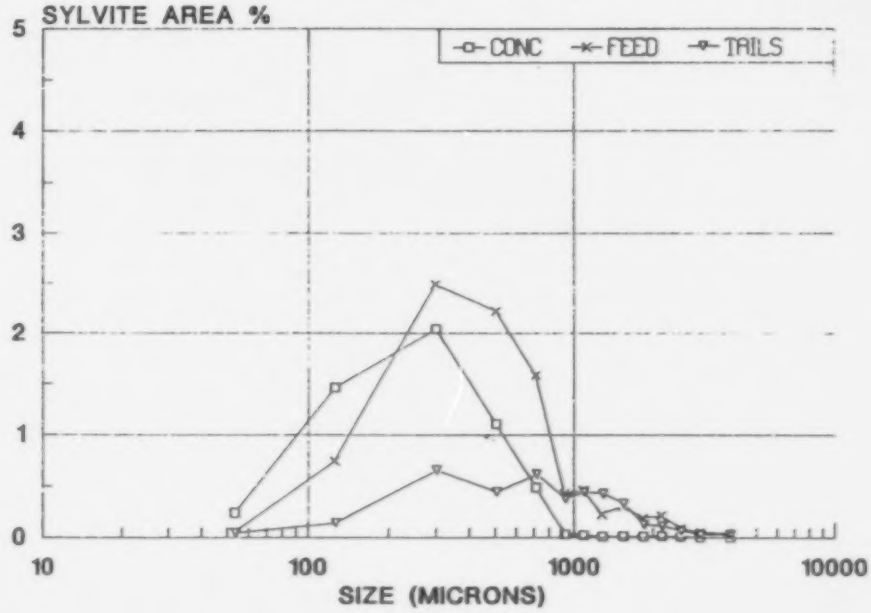
# PCA LIBERATION STUDY

## REGRIND FLOTATION CIRCUIT AUG. 27/87



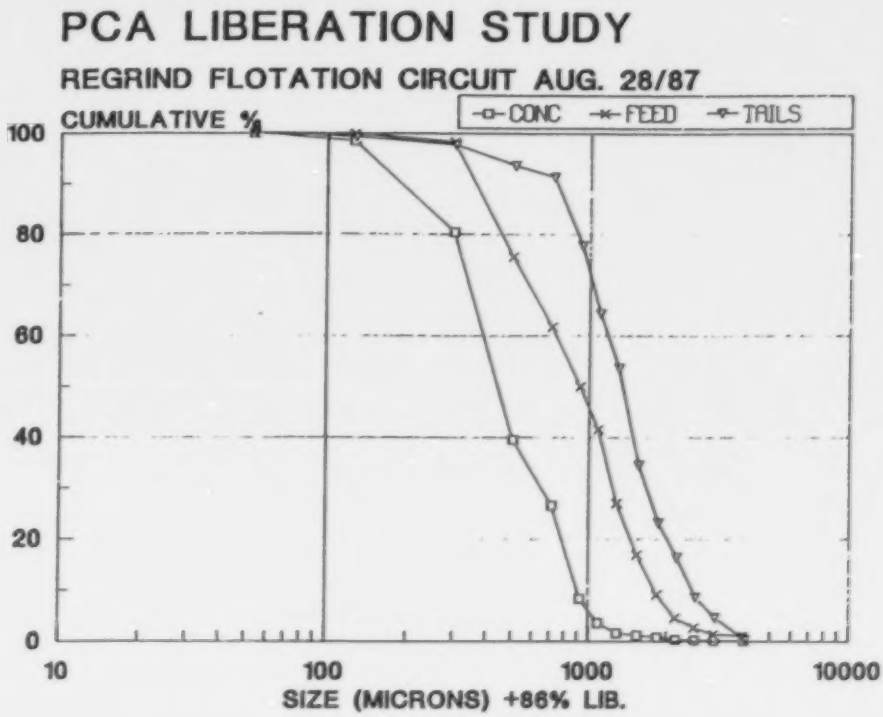

A

## MILL BALANCE REGRIND FLOTATION CIRCUIT AUG. 27/87

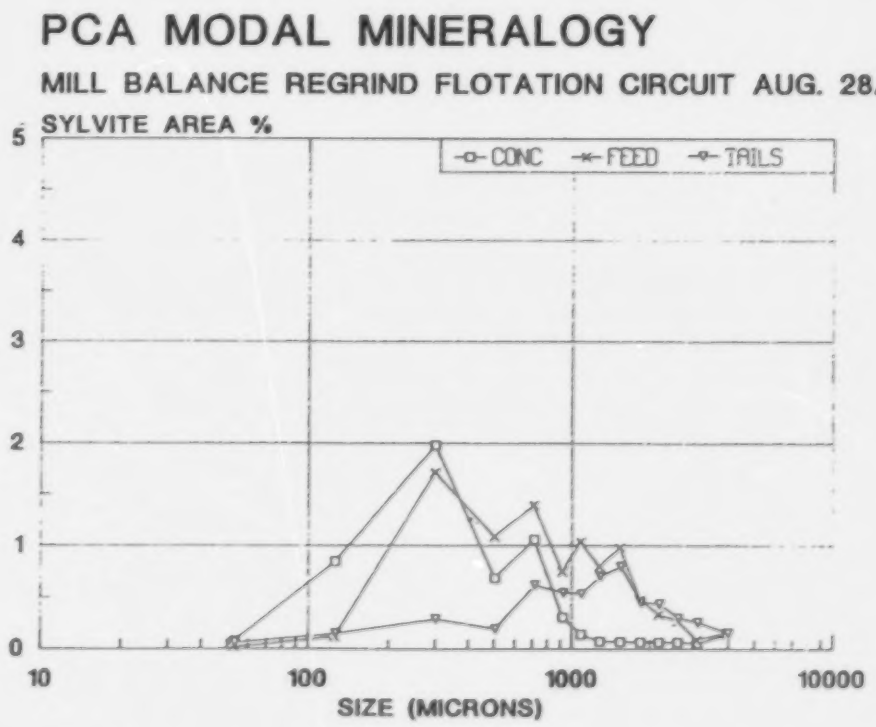



B

**FIGURE 18** Liberation curves (A) and weighted modal mineralogy (B) for the regrind flotation circuit, August 27. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.




A




B

**FIGURE 19** Liberation curves (A) and weighted modal mineralogy (B) for the regrind flotation circuit, August 28. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

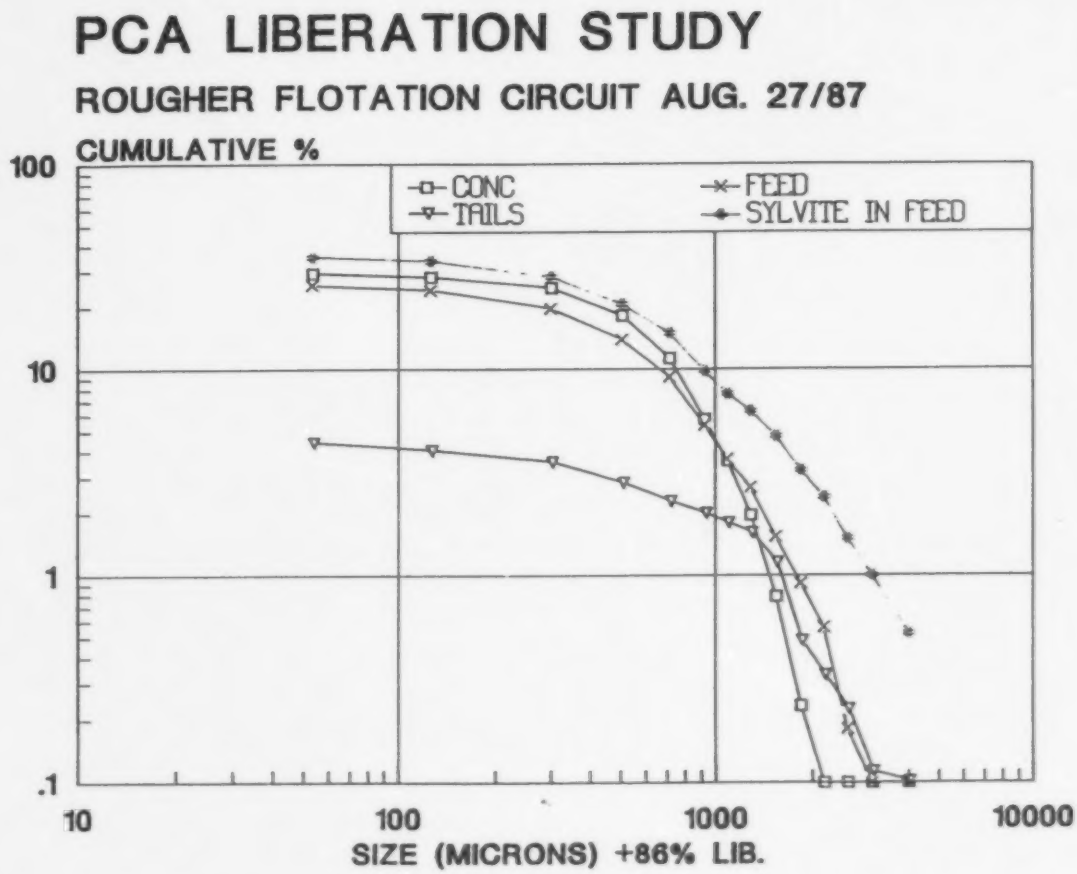



**FIGURE 20** Weighted liberation curves for the rougher flotation circuit, August 27. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.

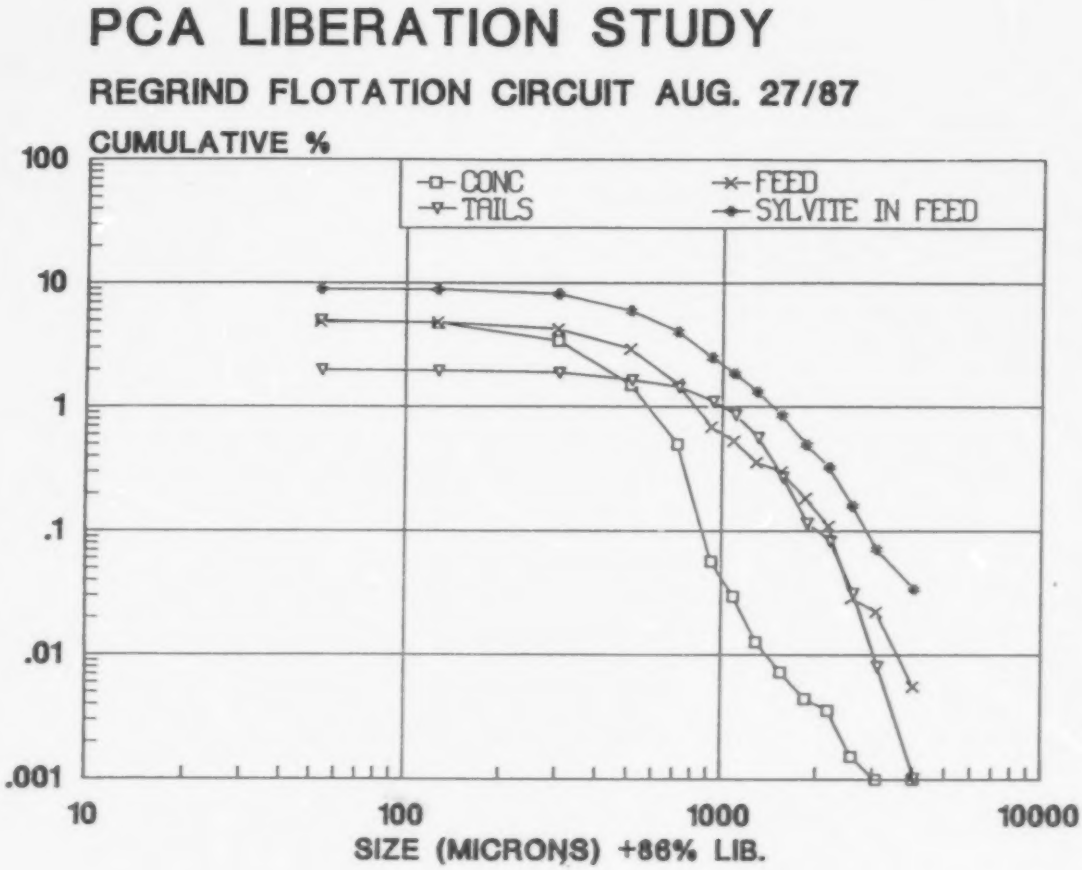



**FIGURE 21** Weighted liberation curves for the regrind flotation circuit, August 27. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.

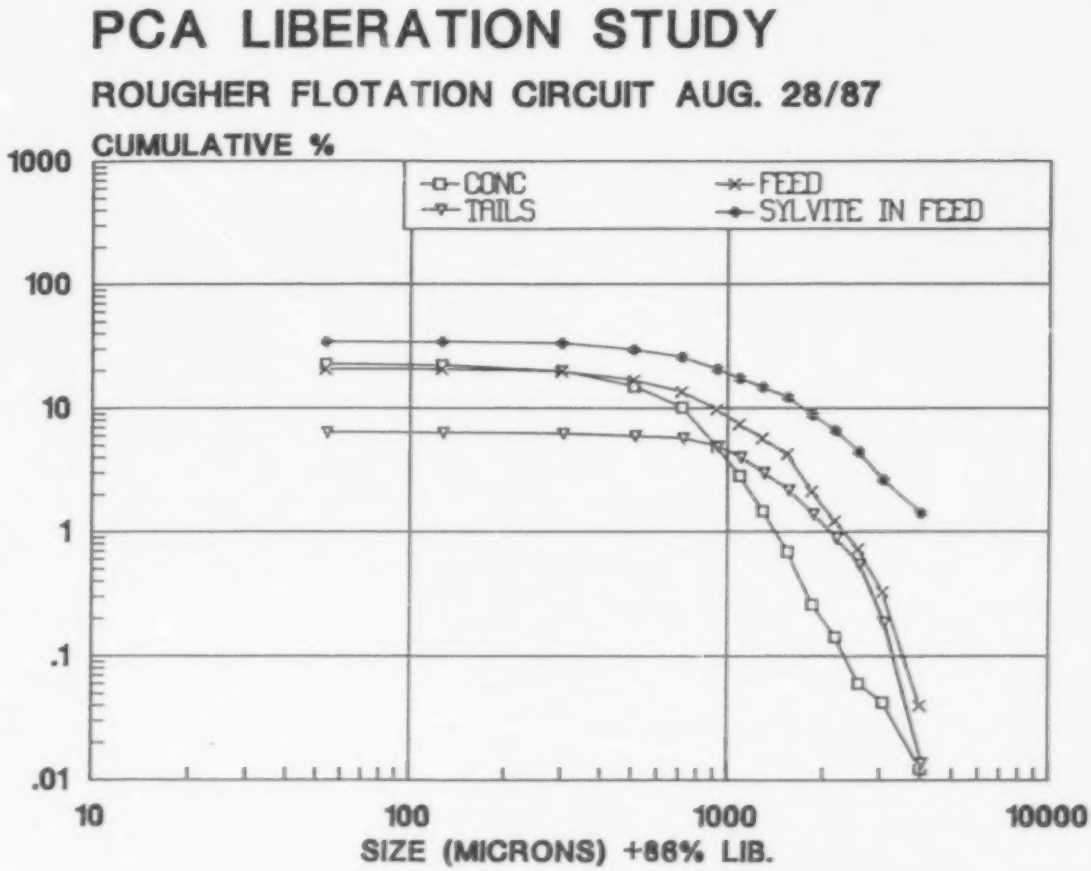



FIGURE 22 Weighted liberation curves for the rougher flotation circuit, August 28. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.

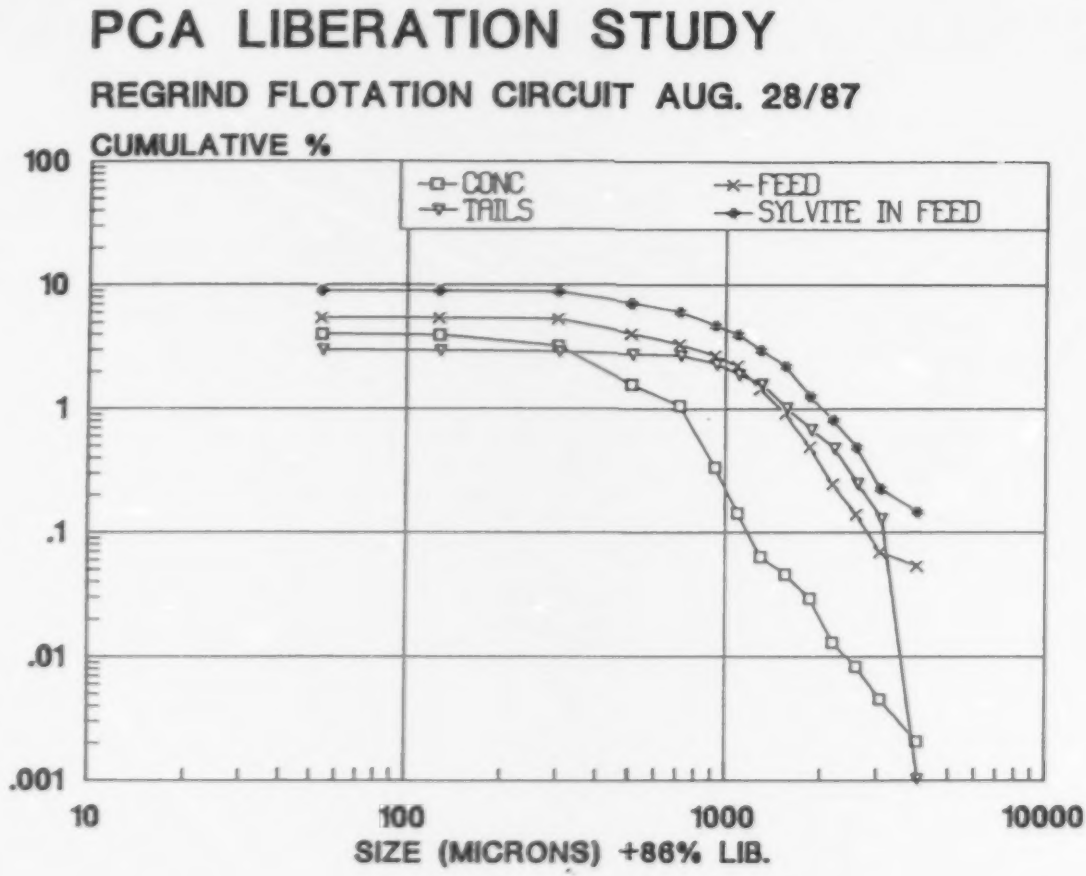



FIGURE 23 Weighted liberation curves for the regrind flotation circuit, August 28. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.

## 7.0 CONCLUSIONS

The composition of the ore is variable across the sylvinite bed with no obvious systematic variations. The texture of the ore can be best described as gneissic and this results in very irregular grain boundaries which may cause problems in achieving a good liberation. The metamorphic grade of the deposit is probably lower greenschist as inferred from the clay mineralogy and the boron minerals.

Salt horses have a Br chemistry similar to the ore and texturally the halite replaced the sylvite. The salt horses are likely the result of NaCl saturated brines dissolving the sylvite and precipitating halite in channel ways in the sylvinite.

In all of the mill sample suites, the grind is too coarse and the some of the coarse liberated sylvite is not being floated. The difference in recovery between August 27 and 28, was do to a coarser grind in both the rougher circuit and the regrind circuit on August 28.

## 8.0 RECOMMENDATIONS

To further understand the genesis of salt horses fluid inclusion and isotopic studies should be undertaken. This should give an indication as to the origin of the brine and its composition.

To better determine the metamorphic grade of the deposit, the fluid inclusions should be studied and the clay and boron assemblages further studied. It may be necessary to produced these assemblages experimentally.

The grain size distribution in the milling of the ore should be narrower. There should be no material coarser than 1000 microns, however, the ore should not be finer than 100 microns. Bench followed by pilot plant tests should be carried out in order to determine the best way to narrow the grain size distribution.

Tests should be carried out to improve the flotation of coarse liberated sylvite. The mill personnel have observed that the non-floating coarse sylvite has a dark red colour. No reasons for this colouration were found during the preliminary mineralogical investigations. A more extensive mineralogical studies should be preformed.

If changes are made to the circuits, another image analysis survey would be useful in order to evaluate the changes and find other areas where improvements could be made.

## REFERENCES

**Brindley,G. W. and Brown, G.** (Eds.) 1984: Crystal Structures of Clay Minerals and Their X-ray Identification, Mineralogical Society Monograph No. 5, 495p.

**Burns, P. C.**, 1988: Hexaborates from the Cassidy Lake Formation Sussex, New Brunswick, Unpub. Undergraduate Thesis, Dept. of Geology, University of New Brunswick, 77p.

**Herrmann, A. G.**, 1980: Bromide distribution between halite and NaCl-saturated seawater, Chemical Geology 28, 171-177.

**Hoffman, S.J., Crosby, K.S., and Irvine J.A.**, 1987: A Lithogeochemical Approach to Stratigraphical Problems of the Millstream Potash Deposit, New Brunswick, Canada, Journal of geochemical Exploration 28, 103-117.

**Linn, K. O., and Adams, S. S.**, 1961: Barren halite zones in potash deposits Carlsbad, New Mexico, In: Second Symposium on Salt, Jon L. Ran Ed., 1961, The Northern Ohio Geological Society Inc., Cleveland, Ohio, 59-69.

**McIntosh, R. A. and Wardlaw, K. C.**, 1968: Barren halite bodies in the sylvinite mining zone at Esterhazy, Saskatchewan, Can. J. Earth Sci. 5, 1221-1238.

**Petruk, W.**, 1986: The MP-SEM-IPS Image Analysis System and Its Application ot Mineralogy and Geochemistry, CANMET Mineral Sciences Laboratories Division Report MSL 86-78, 25p.

**Petruk, W., Pinard, R.G., and Finch, J.**, 1986: Relationship between observed mineral liberations in screened fractions and in composite samples. Minerals and Metallurgical Processing 3, 60-62.

**Roulston, B.V. and Waugh, D.C.E.**, 1983: Stratigraphic Comparison of the Mississippian Potash Deposits in New Brunswick, Canada in Sixth Internation Symposium on Salt 1, 115-130.

**Stirling, J. A. R., Roulston, B., and Waugh, D. C. E.**, 1988: Preliminary Results of the Bromine and Partitioning in the Salt Deposits at Sussex, New Brunswick (Abstr.) Atlantic Geoscience Society 1988 Mtg. In: Maritime Sediments and Atlantic Geology, **24**, 213-214.

**Stirling, J. A. R., Kashani, B., and Nance, D.**, 1983: Geochemistry of selected rocks, Vacherie salt dome, Louisiana, La. State Univ. at B.R., Inst. Envir. Studies Topical Report E530-02200-T-8.

**Stoessell, R. K. and Carpenter, A. B.**, 1986: Stoichiometric saturation tests of $NaCl_{1-x}Br_x$ and $KCl_{1-x}Br_x$, Geochim. Cosmochim. Acta **46**, 1465-1474.

**Srodon, Jan and Eberl, D.D.**, 1984: Illites, In: Bailey, S. W. (Ed.), Micas, Mineralogical Society of America Reviews in Mineralogy, **13**, 495-544.

**Walker, T. R., Waugh, B. and Crone, A. J.**, 1978: Diagenesis in first-cycle desert alluvium of Cenozoic age, southwestern United States and northwestern Mexico, Geol. Soc. Amer. Bull. **89**, 19-32.

**Waugh, D.C.E., and Urquhard**, 1983: The Geology of Denison-Potacan's New Brunswick Potash Deposit in Sixth International Symposium on Salt Vo. 1, 85-98.

# APPENDIX A-1
# SAMPLE CATALOGUE

| NO. | DESCRIPTION | PCA |
|---|---|---|

Note: Due to budget constraints not all samples collected were studied in detail.

Samples 5001 to 5015 collected across the sylvinite ore unitat 1500-1 stope.

| | |
|---|---|
| 5001 | Apr. 22, 1985. Main or 1st Halite Marker |
| 5002 | Apr. 22, Ore between 1st and 2nd Marker |
| 5003 | Apr. 22, 2nd Marker |
| 5004 | Liwer Gradational Bed (L.G.B.) |
| 5005 | Apr. 22, Hanging Wall (H.W.) 2 ft |
| 5006 | Apr. 22, H.W. 10 ft. |
| 5007 | Apr. 22, H.W. 20 ft. |
| 5008 | 1500-1 30 ft. |
| 5009 | 1500-1 40 ft. |
| 5010 | 1500-1 50 ft. |
| 5011 | 1500-1 60 ft. |
| 5012 | 1500-1 70 ft. |
| 5013 | 1500-1 80 ft. |
| 5014 | 1500-1 90 ft., Apr. 22 |
| 5015 | 1500-1 100 ft., Apr. 22, 1985 Salt Marker? |
| 5016 | DDH #H-5 2400 ft. contract argillite/clean halite for Thin Section (T.S.) |
| 5017 | DDH #H-5 2420 ft. for chem anal. Br |
| 5018 | DDH #H-5 2600 ft. for chem anal. Br |
| 5019 | DDH #H-5 2640 ft. chem anal. Br |
| 5020 | DDH #H-5 2890 ft. chem anal. Br |
| 5021 | DDH #E-3 2879 ft. chem anal. and T.S. |
| 5022 | DDH #H-5 2325 ft. Borates T.S chem anal. |
| 5023 | DDH H-5 2300 ft. chem anal. |
| 5024 | DDH H-5 2275 ft. T.S. Textures |
| 5025 | DDH B-3 2088 ft. T.S. Textures |
| 5026 | Upper Halite finely laminate T.S. Textures |
| 5027 | DDH #B-3 2093 ft. Contact Basal anhydrite with Basal Halite |

| NO. | DESCRIPTION | PCA |
|---|---|---|
| 5076 | PCA contact with salt horse, 1940 level, 1092' salt horse in foot wall, 2 chem anal sample A&B | |
| 5077 | Halite w. anhydrite which may be cross bedding 3 chem. anal. - A, B, C - Br. | |
| 5078 | 1940 level stope 1660 4th | |
| 5079 | 1500-2 at end 588' near H.W. | |
| 5080 | 1940 level 860 4th lift | |
| 5081 | 1940 at 870 clay at footwall see section | |
| 5082 | Core with salt horse and marker bed | |
| 5083 | Large sample with salt horse | |
| 5084 | Large sample with salt horse | |
| 5085 | 1900-2 E. Tail. ramp Bottom "clay" | |
| 5086 | Anhydrite after gypsum ?? core | |
| 5087 | "Purple" halite core | |
| 5088 | "Purple" halite core | |
| 5089 | "Purple" halite core | |
| 5090 | "Purple" halite core | |
| 5091 | "Purple" halite core | |
| 5092 | 1900-2 E. Tail ramp bottom - deformed salt - may have recovery problems. | |
| 5093 | Potash Coarse Concentrate June 86. | |
| 5094 | Head - Slimes centrifuge effluent June 86. | |
| 5095 | Head Slimes Centrifuge Cake June 86. | |
| 5096 | Slimes Thickener Feed June 86. | |
| 5097 | Head Reground Rougher Tails June 86. | |
| 5098 | Head Mixed Tailings June 86. | |
| 5099 | Head rougher Flotation Feed (no regrind material) June 86. | |
| 5100 | Head Rougher Tails Screen Oversize June 86. | |
| 5101 | Head Rougher Flotation Concentrate June 86. | |
| 5102 | Head Rougher Flotation Cells June 86. | |
| 5103 | Head Slimes Centrifuge June 86. | |
| 5104 | Final Tails June 86. | |

| NO. | DESCRIPTION | PCA |
|---|---|---|
| 5113 | XC 130 from drill core just above ore zone | |
| 5114 | PCA spl. location: Intersection of 1850 vent drift AN 91XCS (middle halite) | |
| 5115 | PCA bright red coarse sylvite - R. F. Tails, does not float | |
| 5131 | PCA mill product Aug. 27, 1987. | |
| 5132 | Rougher flot. feed Aug. 27th, 1987 | |
| 5133 | Rougher flot. tails Aug. 27th, 1987 | |
| 5134 | Rougher flot. concentrate Aug. 27, 1987 | |
| 5135 | Ball mill feed Aug. 27, 1987 | |
| 5136 | Ball mill Disclarge Aug. 27, 1987 | |
| 5137 | Regrind flot. concentrate Aug. 27, 1987 | |
| 5138 | Regrind flot. tails Aug. 27, 1987 | |
| 5139 | Slimes thickener U/F Aug. 27, 1987 | |
| 5140 | Regrind flot. concentrate Aug. 28, 1987 | |
| 5141 | Rougher flot. tails Aug. 28, 1987 | |
| 5142 | Regrind flotation tailings Aug. 28, 1987 | |
| 5143 | Ball Mill discharge Aug. 28, 1987 | |
| 5144 | Rougher flot. feed Aug. 28, 1987 | |
| 5145 | Ball mill feed Aug. 28, 1987 | |
| 5146 | Rougher flotation concentrate Aug. 28, 1987 | |
| 5147 | Spherical insol. minerals PCA Sussex 1900-3 East tailings ramp 184 Section middle ore, salt horse | |
| 5212 | 1850 Cl of upper halite | Xray sample #1 |
| 5213 | 1900-3 sill cut<br>H.W. salt horst. | Xray sample #2 |
| 5214 | 1900-1 stope, 18th lift, 106 + 50, clay seam contact - A zone/L. G.Z. (1) | Xray sample #4 |
| 5215 | 1900-1 stope<br>18th lift, 106 + 50, clay seam contact - A zone/<br>LGZ (2) | Xray sample #5 |
| 5216 | 1850 exploration drift, middle of salt horst<br>Xray sample #6 | |

| NO. | DESCRIPTION | PCA |
|---|---|---|
| 5217 | 1500-1 KL (base of) (1) | Xray sample #7 |
| 5218 | 1500-1 Kl (base of) (2) | Xray sample #8 |
| 5219 | 1500-1, A zone in area of salt horst | Xray sample #9 |
| 5220 | Footwal 1850 level, 193 + 50 secton | Xray sample #10 |
| 5221 | 1900-6 drift, 170 section, base of transitional zone at top of basal halite. Xray sample #11 | |

# APPENDIX A-2
# BR CONTENT OF HALITE AND SYLVITE

PCA HALITE 5023

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| HALITE | 39.31 | .00 | 59.27 | 20 | 98.58 |
| | 39.91 | .08 | 61.31 | 90 | 101.31 |
| | 39.73 | .04 | 60.76 | 192 | 100.55 |
| | 40.08 | .06 | 61.86 | 42 | 102.00 |
| | 39.62 | .06 | 60.87 | 0 | 100.55 |
| | 40.59 | .06 | 61.36 | 0 | 102.01 |
| | 39.75 | .04 | 60.96 | 0 | 100.75 |
| | 40.25 | .02 | 62.57 | 153 | 102.86 |
| | 40.92 | .08 | 63.23 | 176 | 104.25 |
| | 40.37 | .00 | 61.31 | 0 | 101.68 |
| | 39.81 | .08 | 61.61 | 26 | 101.50 |
| | 40.17 | .02 | 62.01 | 0 | 102.20 |
| | 40.36 | .08 | 62.12 | 54 | 102.57 |
| | 40.02 | .03 | 65.93 | 16 | 105.98 |
| | 39.53 | .07 | 61.46 | 0 | 101.06 |
| | 38.88 | .03 | 60.06 | 54 | 98.98 |
| | 39.26 | .07 | 61.12 | 38 | 100.45 |
| | 39.34 | .04 | 60.44 | 0 | 99.82 |
| | 39.06 | .05 | 61.72 | 48 | 100.83 |
| | 39.53 | .04 | 62.46 | 0 | 102.03 |

PCA ORE 5034

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .05 | 52.89 | 44.87 | 473 | 97.86 |
| | .03 | 53.39 | 47.82 | 1221 | 101.36 |
| | .14 | 52.98 | 46.97 | 1052 | 100.20 |
| | .01 | 53.63 | 45.85 | 500 | 99.54 |
| | .93 | 52.96 | 47.84 | 985 | 101.83 |
| | .05 | 54.13 | 47.39 | 3635 | 101.93 |
| | .04 | 53.49 | 44.39 | 2439 | 98.16 |
| | .02 | 54.52 | 46.07 | 3848 | 100.99 |
| | .14 | 53.51 | 47.02 | 3353 | 101.01 |
| | .05 | 54.83 | 46.76 | 535 | 101.69 |
| | .02 | 53.65 | 44.83 | 420 | 98.54 |
| | .23 | 53.74 | 45.58 | 3336 | 99.88 |
| | .08 | 53.90 | 45.87 | 2870 | 100.14 |
| | .09 | 53.76 | 45.58 | 3167 | 99.75 |
| | .04 | 53.53 | 45.20 | 2686 | 99.04 |
| | .07 | 52.95 | 44.93 | 4000 | 98.35 |
| | .11 | 53.55 | 44.98 | 3164 | 98.96 |
| | .10 | 53.44 | 45.53 | 2338 | 99.30 |
| | .04 | 54.46 | 46.95 | 2743 | 101.72 |
| | .09 | 54.04 | 46.89 | 250 | 101.05 |
| HALITE | 39.02 | .03 | 59.92 | 609 | 99.03 |
| | 39.22 | .01 | 58.68 | 166 | 97.93 |
| | 39.03 | .08 | 59.29 | 297 | 98.43 |
| | 38.76 | .11 | 58.97 | 609 | 97.90 |
| | 38.85 | .04 | 58.29 | 235 | 97.20 |
| | 38.87 | .20 | 58.26 | 204 | 97.35 |
| | 38.90 | .12 | 59.52 | 125 | 98.55 |
| | 38.55 | .23 | 57.27 | 590 | 96.11 |
| | 38.84 | .09 | 60.03 | 508 | 99.01 |
| | 39.17 | .29 | 60.68 | 302 | 100.17 |
| | 39.01 | .10 | 58.22 | 499 | 97.38 |
| | 39.13 | .00 | 58.54 | 410 | 97.71 |
| | 38.87 | .11 | 60.03 | 274 | 99.04 |
| | 38.00 | .00 | 58.03 | 300 | 96.06 |
| | 39.25 | .10 | 59.92 | 422 | 99.31 |
| | 40.17 | .03 | 57.95 | 123 | 98.16 |
| | 39.00 | .02 | 60.33 | 486 | 99.40 |
| | 39.72 | .10 | 59.57 | 417 | 99.43 |
| | 38.46 | .08 | 59.57 | 143 | 98.12 |
| | 39.96 | .09 | 58.45 | 440 | 98.54 |

PCA SALT HORSE 5042A

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .12 | 56.74 | 46.67 | 1993 | 103.73 |
| | .15 | 55.08 | 45.04 | 1934 | 100.46 |
| | .27 | 54.57 | 46.06 | 1103 | 101.01 |
| | .33 | 55.83 | 45.74 | 854 | 101.99 |
| | .12 | 55.19 | 46.60 | 935 | 102.00 |
| | .74 | 55.12 | 46.86 | 991 | 102.82 |
| | .23 | 54.62 | 46.32 | 1226 | 101.29 |
| | .06 | 55.03 | 45.36 | 2477 | 100.70 |
| | .19 | 54.96 | 46.43 | 2293 | 101.81 |
| | 1.31 | 54.64 | 46.33 | 1577 | 102.44 |
| | 1.11 | 55.08 | 46.08 | 2817 | 102.55 |
| | .51 | 55.12 | 46.39 | 1095 | 102.13 |
| | .25 | 56.52 | 47.22 | 1374 | 104.13 |
| | .21 | 57.19 | 46.56 | 3934 | 104.35 |
| | .17 | 57.14 | 46.91 | 2214 | 104.44 |
| | .07 | 56.25 | 45.57 | 2188 | 102.11 |
| | 1.61 | 54.37 | 45.78 | 1606 | 101.92 |
| | .34 | 55.44 | 46.09 | 1210 | 101.99 |
| | .26 | 56.20 | 46.98 | 1973 | 103.64 |
| | .18 | 56.83 | 46.32 | 2151 | 103.55 |
| HALITE | 40.46 | .04 | 59.06 | 0 | 99.56 |
| | 41.61 | .10 | 60.35 | 164 | 102.08 |
| | 40.82 | .03 | 62.06 | 315 | 102.94 |
| | 40.50 | .09 | 59.85 | 31 | 100.44 |
| | 40.83 | .08 | 60.73 | 376 | 101.68 |
| | 40.24 | .04 | 61.10 | 106 | 101.39 |
| | 39.99 | .08 | 60.18 | 260 | 100.28 |
| | 40.05 | .06 | 60.11 | 56 | 100.23 |
| | 41.34 | .17 | 60.62 | 189 | 102.15 |
| | 40.74 | .06 | 59.57 | 145 | 100.38 |
| | 40.51 | .12 | 60.36 | 448 | 101.03 |
| | 41.56 | .15 | 60.09 | 384 | 101.84 |
| | 41.44 | .11 | 61.86 | 0 | 103.41 |
| | 40.78 | .07 | 59.58 | 211 | 100.45 |
| | 40.25 | .06 | 60.90 | 188 | 101.23 |
| | 40.21 | .09 | 60.66 | 347 | 100.99 |
| | 39.42 | .16 | 61.08 | 296 | 100.69 |
| | 40.12 | .07 | 59.89 | 154 | 100.10 |
| | 40.39 | .09 | 58.35 | 101 | 98.84 |
| | 39.87 | .04 | 59.13 | 267 | 99.07 |

POTACAN ORE 5064

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .13 | 50.34 | 46.36 | 2343 | 97.06 |
| | .11 | 50.48 | 46.83 | 2098 | 97.63 |
| | .17 | 50.39 | 46.80 | 2326 | 97.59 |
| | .15 | 50.41 | 47.19 | 2377 | 97.99 |
| | .22 | 50.49 | 47.49 | 2267 | 98.42 |
| | .22 | 50.06 | 46.61 | 2114 | 97.10 |
| | .16 | 49.65 | 47.56 | 2103 | 97.58 |
| | .17 | 51.28 | 47.83 | 2527 | 99.53 |
| | .12 | 50.79 | 47.60 | 2210 | 98.73 |
| | .24 | 51.08 | 46.80 | 1607 | 98.28 |
| | .14 | 51.28 | 46.92 | 2275 | 98.57 |
| | .15 | 51.53 | 47.35 | 1845 | 99.21 |
| | .13 | 51.72 | 46.39 | 2036 | 98.44 |
| | .18 | 51.00 | 47.31 | 2024 | 98.69 |
| | .14 | 51.31 | 47.53 | 2265 | 99.21 |
| | .21 | 50.90 | 47.18 | 1996 | 98.49 |
| | .32 | 50.75 | 47.80 | 2137 | 99.08 |
| | .17 | 50.58 | 47.08 | 1199 | 97.95 |
| | .19 | 50.78 | 46.95 | 2389 | 98.16 |
| | .18 | 51.08 | 48.22 | 1426 | 99.62 |
| HALITE | 40.51 | .02 | 61.29 | 73 | 101.83 |
| | 41.73 | .05 | 61.47 | 224 | 103.27 |
| | 40.94 | .00 | 60.78 | 21 | 101.72 |
| | 41.42 | .08 | 60.82 | 52 | 102.33 |
| | 40.97 | .08 | 61.41 | 66 | 102.47 |
| | 40.75 | .08 | 61.01 | 341 | 101.87 |
| | 40.09 | .02 | 60.88 | 229 | 101.01 |
| | 40.35 | .02 | 61.84 | 265 | 102.24 |
| | 41.04 | .03 | 61.15 | 62 | 102.23 |
| | 40.68 | .03 | 60.17 | 181 | 100.90 |
| | 40.18 | .01 | 61.20 | 212 | 101.41 |
| | 40.14 | .06 | 60.88 | 257 | 101.11 |
| | 41.05 | .01 | 60.93 | 0 | 101.99 |
| | 40.31 | .11 | 60.85 | 422 | 101.31 |
| | 40.08 | .03 | 60.79 | 73 | 100.91 |
| | 40.52 | .04 | 60.80 | 144 | 101.37 |
| | 40.32 | .10 | 61.37 | 270 | 101.82 |
| | 40.01 | .05 | 60.52 | 129 | 100.59 |
| | 40.21 | .10 | 60.08 | 152 | 100.41 |
| | 40.97 | .07 | 61.04 | 187 | 102.10 |

POTACAN ORE 5065

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .30 | 51.44 | 44.21 | 2689 | 96.22 |
| | .17 | 51.75 | 44.04 | 1954 | 96.16 |
| | 1.21 | 50.27 | 44.68 | 509 | 96.21 |
| | .23 | 52.02 | 44.48 | 983 | 96.83 |
| | .42 | 50.79 | 44.67 | 1083 | 95.99 |
| | .53 | 51.63 | 45.87 | 3515 | 98.38 |
| | .23 | 51.83 | 44.05 | 3552 | 96.47 |
| | .19 | 51.62 | 44.70 | 1293 | 96.64 |
| | .86 | 49.79 | 44.22 | 1195 | 94.99 |
| | .40 | 50.06 | 44.07 | 2363 | 94.77 |
| HALITE | 39.35 | .08 | 57.88 | 105 | 97.32 |
| | 40.23 | .08 | 57.04 | 197 | 97.37 |
| | 39.66 | .05 | 56.93 | 171 | 96.66 |
| | 39.41 | .11 | 57.40 | 21 | 96.92 |
| | 39.41 | .08 | 57.24 | 42 | 96.73 |
| | 39.99 | .04 | 57.53 | 0 | 97.56 |
| | 39.92 | .09 | 57.46 | 129 | 97.48 |
| | 38.68 | .16 | 55.84 | 302 | 94.71 |
| | 39.66 | .04 | 57.51 | 160 | 97.23 |
| | 40.00 | .04 | 57.93 | 203 | 97.99 |

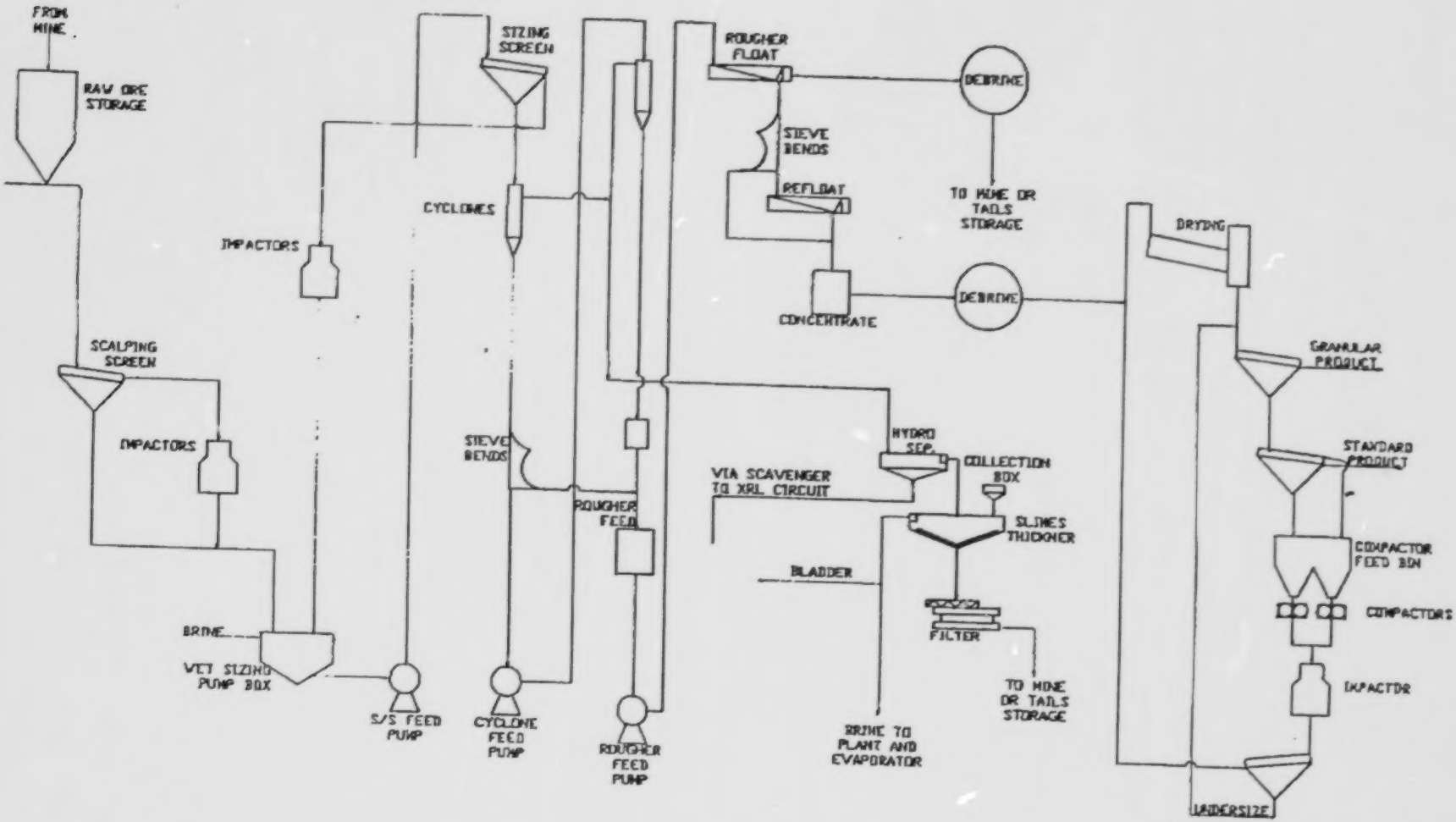
POTACAN HORSE 5070

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .18 | 50.89 | 45.27 | 2096 | 96.55 |
| | .30 | 50.89 | 47.22 | 2235 | 98.63 |
| | .28 | 50.76 | 47.22 | 1024 | 98.36 |
| | .36 | 50.66 | 46.55 | 1224 | 97.69 |
| | .28 | 51.06 | 46.23 | 2114 | 97.78 |
| | .70 | 51.13 | 48.01 | 2102 | 100.05 |
| | .17 | 51.09 | 47.63 | 1862 | 99.08 |
| | .31 | 51.16 | 47.12 | 1225 | 98.71 |
| | .30 | 51.72 | 47.10 | 1096 | 99.23 |
| | .79 | 51.42 | 48.14 | 1333 | 100.48 |
| HALITE | 40.15 | .07 | 61.16 | 156 | 101.40 |
| | 39.80 | .01 | 61.63 | 159 | 101.46 |
| | 40.47 | .02 | 61.18 | 312 | 101.70 |
| | 39.74 | .06 | 62.07 | 64 | 101.88 |
| | 40.02 | .09 | 61.48 | 147 | 101.60 |
| | 39.78 | .07 | 61.48 | 163 | 101.35 |
| | 40.00 | .08 | 62.10 | 48 | 102.18 |
| | 39.12 | .02 | 60.95 | 244 | 100.11 |
| | 40.02 | .08 | 61.83 | 321 | 101.96 |
| | 39.82 | .05 | 62.20 | 89 | 102.08 |
| | 40.07 | .02 | 62.33 | 87 | 102.43 |
| | 39.73 | .06 | 63.27 | 56 | 103.07 |
| | 40.03 | .04 | 61.93 | 106 | 102.01 |
| | 39.92 | .07 | 60.83 | 64 | 100.83 |
| | 39.69 | .04 | 61.86 | 202 | 101.61 |
| | 39.63 | .01 | 62.01 | 68 | 101.66 |
| | 39.25 | .04 | 62.93 | 113 | 102.23 |
| | 39.75 | .06 | 62.12 | 54 | 101.94 |
| | 39.77 | .01 | 61.93 | 118 | 101.72 |
| | 39.65 | .05 | 61.76 | 194 | 101.48 |

# APPENDIX A-3

# PCA CONCENTRATOR FLOWSHEET

# SUSSEX SIMPLIFIED FLOW DIAGRAM



# APPENDIX A-4
# CHEMICAL COMPOSITION OF MILL SAMPLES
# COLLECTED JUNE 1986

TABLE 3 CHEMICAL ANALYSIS OF PCA MILL SAMPLES COLLECTED 1986

| DESCRIPTION | C CONC SURGE TANK | SLIMES CENT EFFLU | SLIMES CENT CAKE | SLIMES THICK FEED | REGRND ROUGH TAILS | MIXED TAILS | ROUGH FLOT FEED | R TAIL SCREEN O SIZE | ROUGH FLOT CONC | ROUGH FLOT TAILS | SLIMES CENT | FINAL TAILS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5093 | 5094 | 5095 | 5096 | 5097 | 5098 | 5099 | 5100 | 5101 | 5102 | 5103 | 5104 |
| WT% | | | | | | | | | | | | |
| K | 45.05 | 7.25 | 9.89 | 20.00 | 7.79 | 4.11 | 18.74 | 9.44 | 36.43 | 7.87 | 13.27 | 2.94 |
| CA | .62 | 1.53 | 1.62 | 1.26 | .54 | .42 | .61 | 1.07 | .85 | .79 | 1.78 | .73 |
| NA | 2.46 | 5.01 | 18.80 | 12.55 | 28.41 | 32.37 | 22.05 | 30.50 | 7.54 | 31.01 | 17.29 | 33.51 |
| CL | 46.30 | 14.35 | 42.40 | 40.50 | 55.85 | 58.65 | 53.20 | 52.95 | 50.15 | 54.8 | 39.10 | 53.25 |
| SO4 | .51 | 3.67 | 2.37 | 1.51 | .37 | .25 | .21 | .24 | .25 | .23 | 2.29 | .18 |
| INSOLUBLES | 4.66 | 57.20 | 16.25 | 14.70 | 5.09 | 4.84 | 4.46 | 7.20 | 7.27 | 5.75 | 24.00 | 8.95 |
| PPM | | | | | | | | | | .82 | | |
| MG | 359 | 7185 | 1945 | 1959 | 473 | 503 | 572 | 535 | 756 | 378 | 2656 | 402 |
| FE | 1131 | 35150 | 4028 | 5536 | 501 | 589 | 727 | 609 | 1186 | 652 | 9000 | 657 |
| MN | <10 | 133 | 18 | 7 | 7 | 17 | 14 | <10 | <10 | 8 | 78 | 27 |
| ZN | 5 | 61 | 22 | 27 | 10 | <10 | <10 | <10 | <10 | 7 | 34 | 15 |
| BR | 1378 | 622 | 649 | 479 | 598 | 335 | 748 | 536 | 1178 | 509 | 647 | 356 |
| SR | <10 | 57 | 45 | 32 | 6 | 8 | <10 | 7 | <10 | <10 | <10 | <10 |
| RB | 37 | 36 | 31 | 33 | 18 | 14 | 20 | 16 | 26 | 13 | 23 | 7 |
| B | 4 | 131 | 43 | 46 | 7 | 8 | 9 | 6 | 6 | 6 | 63 | 13 |
| TOTAL | 99.88 | 93.35 | 92.00 | 91.33 | 98.20 | 100.79 | 99.47 | 101.57 | 102.80 | 100.60 | 98.98 | 99.70 |
| NORM | | | | | | | | | | | | |
| SYLVITE K | 85.89 | 13.82 | 18.85 | 38.13 | 14.84 | 7.84 | 35.73 | 18.00 | 69.46 | 15.01 | 25.30 | 5.60 |
| HALITE NA | 6.24 | 12.74 | 47.79 | 31.89 | 72.22 | 82.29 | 56.05 | 77.53 | 19.17 | 78.82 | 43.95 | 85.17 |
| ANAL. CL | 46.30 | 14.35 | 42.40 | 40.50 | 55.85 | 58.65 | 53.20 | 52.95 | 50.15 | 54.8 | 39.10 | 53.25 |
| CAL. CL | 44.63 | 14.30 | 37.95 | 37.48 | 50.87 | 53.64 | 50.99 | 55.59 | 44.66 | 54.95 | 38.69 | 54.33 |
| ANHYDRITE | 2.09 | 5.20 | 5.50 | 4.28 | 1.83 | 1.43 | 2.07 | 3.63 | 2.89 | 2.68 | 6.05 | 2.48 |
| CAL SO4 | 1.47 | 3.67 | 3.88 | 3.02 | 1.29 | 1.01 | 1.46 | 2.56 | 2.04 | 1.89 | 4.27 | 1.75 |
| INSOLUBLES | 4.66 | 57.20 | 16.25 | 14.70 | 5.09 | 4.84 | 4.46 | 7.20 | 7.27 | 5.75 | 24.00 | 8.95 |
| NORM TOTAL | 98.88 | 88.96 | 88.39 | 89.00 | 93.98 | 96.39 | 98.31 | 106.37 | 98.78 | 102.25 | 99.30 | 102.20 |

RESEARCH AND PRODUCTIVITY COUNCIL

# APPENDIX A-5
# SIEVE ANALYSIS, MODAL MINERALOGY AND LIBERATION DATA, JUNE 1986

TABLE SIEVE ANALYSIS OF PCA MILL SAMPLES COLLECTED BEFORE INSTALLATION OF REGRIND CIRCUIT

NORMALIZED

| SAMPLE | 5093 | 5094 | 5095 | 5096 | 5097 | 5098 | 5099 | 5100 | 5101 | 5102 | 5103 | 5104 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -37 NM | .13 | .00 | .15 | .43 | .04 | .20 | .14 | .05 | .29 | .10 | .25 | .20 |
| +37 | .42 | .51 | 2.41 | 6.17 | .26 | .50 | .48 | .14 | 2.14 | .31 | 2.25 | .35 |
| +53 | .32 | 6.67 | 3.97 | 7.32 | .27 | .48 | .42 | .08 | 1.53 | .30 | 4.98 | .49 |
| +75 | 1.47 | 5.47 | 8.23 | 8.95 | 1.64 | 2.57 | 2.01 | .40 | 4.07 | 1.61 | 6.92 | 2.94 |
| +150 | 2.01 | 6.68 | 11.60 | 17.49 | 2.27 | 3.17 | 1.87 | .49 | 5.08 | 1.66 | 7.78 | 3.55 |
| +212 | 4.44 | 9.81 | 11.45 | 9.66 | 3.87 | 5.18 | 3.00 | .93 | 7.17 | 2.98 | 10.38 | 6.08 |
| +300 | 9.43 | 7.46 | 9.00 | 7.30 | 6.52 | 10.23 | 5.79 | 2.23 | 11.05 | 5.32 | 9.46 | 10.97 |
| +425 | 19.72 | 5.84 | 8.56 | 6.87 | 10.89 | 16.05 | 9.93 | 5.41 | 15.82 | 9.31 | 8.41 | 17.16 |
| +600 | 30.71 | 7.10 | 7.91 | 6.51 | 14.82 | 17.99 | 12.76 | 9.21 | 16.40 | 13.34 | 7.91 | 18.78 |
| +850 | 22.02 | 11.44 | 10.08 | 8.09 | 21.24 | 21.41 | 16.95 | 21.70 | 16.79 | 21.37 | 9.78 | 21.86 |
| +1.18 M | 7.83 | 16.67 | 12.58 | 11.87 | 24.47 | 16.04 | 23.37 | 33.83 | 11.97 | 22.88 | 14.70 | 13.85 |
| +1.7 | 1.28 | 16.52 | 10.52 | 7.71 | 12.01 | 5.47 | 17.91 | 23.28 | 6.80 | 17.19 | 14.09 | 3.46 |
| +2.36 | .23 | 5.73 | 3.30 | 1.51 | 1.69 | .73 | 5.23 | 2.07 | .84 | 3.53 | 2.98 | .30 |
| +3.35 | .00 | .10 | .24 | .10 | .02 | .00 | .14 | .18 | .06 | .10 | .09 | .00 |
| +4.7 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| +6.7 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

PCA MODAL MINERALOGY JUNE 1986

COARSE CONCENTRATE (SLURRY TANK) RPC #5093

| FRACTION | SYLVITE AREA % FOR PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | SAMPLE WEIGHTED | MILL WT= .09 SYLVITE AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 32.00 | 12.60 | 76.30 | 11.20 | 14.17 | 85.83 | 12.60 | 88.89 | .13 | .11 | .01 |
| +38 | 45.00 | 7.65 | 84.90 | 7.45 | 8.27 | 36.50 | 8.05 | 97.39 | .42 | .15 | .01 |
| +53 | 63.00 | 7.11 | 85.90 | 6.99 | 7.64 | 92.36 | 7.52 | 98.31 | .32 | .30 | .03 |
| +75 | 106.00 | 4.50 | 91.20 | 4.25 | 4.70 | 95.30 | 4.44 | 94.44 | 1.47 | 1.40 | .13 |
| +150 | 180.00 | 1.05 | 97.90 | 1.02 | 1.06 | 98.94 | 1.03 | 97.14 | 2.01 | 1.99 | .18 |
| +212 | 250.00 | .64 | 98.80 | .59 | .64 | 99.36 | .60 | 92.50 | 4.44 | 4.41 | .40 |
| +300 | 355.00 | .63 | 99.00 | .34 | .64 | 99.36 | .34 | 53.55 | 9.43 | 9.37 | .84 |
| +425 | 500.00 | .44 | 99.30 | .23 | .44 | 99.56 | .23 | 51.95 | 19.72 | 19.63 | 1.77 |
| +600 | 710.00 | 1.24 | 97.80 | .96 | 1.25 | 98.75 | .97 | 77.34 | 30.71 | 30.33 | 2.73 |
| +850 | 1000.00 | .25 | 99.60 | .11 | .25 | 99.75 | .11 | 45.71 | 22.02 | 21.97 | 1.98 |
| +1180 | 1400.00 | 1.36 | 98.00 | .67 | 1.37 | 98.63 | .67 | 49.04 | 7.83 | 7.72 | .70 |
| +1700 | 2000.00 | 6.48 | 92.10 | 1.40 | 6.57 | 93.43 | 1.42 | 21.60 | 1.28 | 1.20 | .11 |
| +2360 | 2800.00 | 5.98 | 91.20 | 2.85 | 6.15 | 93.85 | 2.93 | 47.66 | .23 | .22 | .02 |
| +3350 | 4000.00 | .00 | .00 | .00 | .00 | 100.00 | .00 | .00 | .00 | .00 | .00 |
| | | | | | | | | | | 98.79 | 8.89 |

PCA MODAL MINERALOGY JUNE 1986

REGROUND ROUGHER TAILINGS #5097

| SYLVITE AREA % FRACTION | FOR PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | SAMPLE | MILL WT= .35 WEIGHTED SYLVITE A |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 32.00 | 36.90 | 26.30 | 36.80 | 58.39 | 41.61 | 58.23 | 99.73 | .04 | .02 | .01 |
| +38 | 45.00 | 40.00 | 20.10 | 39.80 | 66.56 | 33.44 | 66.22 | 99.50 | .26 | .09 | .03 |
| +53 | 63.00 | 42.60 | 14.80 | 42.60 | 74.22 | 25.78 | 74.22 | 100.00 | .27 | .07 | .02 |
| +75 | 106.00 | 43.80 | 12.50 | 43.70 | 77.80 | 22.20 | 77.62 | 99.77 | 1.64 | .36 | .13 |
| +150 | 180.00 | 45.20 | 9.69 | 54.10 | 82.35 | 17.65 | 98.56 | 119.69 | 2.27 | .40 | .14 |
| +212 | 250.00 | 44.80 | 10.50 | 44.70 | 81.01 | 18.99 | 80.83 | 99.78 | 3.87 | .73 | .26 |
| +300 | 355.00 | 44.80 | 10.70 | 44.50 | 80.72 | 19.28 | 80.18 | 99.33 | 6.52 | 1.26 | .44 |
| +425 | 500.00 | 45.50 | 9.52 | 45.10 | 82.70 | 17.30 | 81.97 | 99.12 | 10.89 | 1.88 | .66 |
| +600 | 710.00 | 45.80 | 8.71 | 45.50 | 84.02 | 15.98 | 83.47 | 99.34 | 14.82 | 2.37 | .83 |
| +850 | 1000.00 | 44.50 | 11.80 | 43.70 | 79.04 | 20.96 | 77.62 | 98.20 | 21.24 | 4.45 | 1.56 |
| +1180 | 1400.00 | 46.20 | 12.40 | 41.40 | 78.84 | 21.16 | 70.65 | 89.61 | 24.47 | 5.18 | 1.81 |
| +1700 | 2000.00 | 44.70 | 11.30 | 44.00 | 79.82 | 20.18 | 78.57 | 98.43 | 12.01 | 2.42 | .85 |
| +2360 | 2800.00 | 48.10 | 12.20 | 39.70 | 79.77 | 20.23 | 65.84 | 82.54 | 1.69 | .34 | .12 |
| +3350 | 4000.00 | 63.90 | 10.20 | 26.00 | 86.23 | .00 | 35.09 | 40.69 | .02 | .00 | .00 |
| | | | | | | | | | | 19.58 | 6.85 |

PCA MODAL MINERALOGY JUNE 1986

MIXED TAILINGS #5098

| FRACTION | SYLVITE AREA % FOR PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | SAMPLE | MILL WT= .37 WEIGHTED SYLVITE A |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 32.00 | 47.90 | 4.11 | 47.90 | 92.10 | 7.90 | 92.10 | 100.00 | .20 | .02 | .01 |
| +38 | 45.00 | 48.40 | 3.30 | 48.30 | 93.62 | 6.38 | 93.42 | 99.79 | .50 | .03 | .01 |
| +53 | 63.00 | 49.20 | 1.59 | 49.20 | 96.87 | 3.13 | 96.87 | 100.00 | .48 | .02 | .01 |
| +75 | 106.00 | 49.70 | .60 | 49.70 | 98.80 | 1.20 | 98.80 | 100.00 | 2.57 | .03 | .01 |
| +150 | 180.00 | 49.60 | .74 | 49.60 | 98.54 | 1.46 | 98.54 | 100.00 | 3.17 | .05 | .02 |
| +212 | 250.00 | 49.70 | .77 | 49.50 | 98.47 | 1.53 | 98.07 | 99.60 | 5.18 | .08 | .03 |
| +300 | 355.00 | 49.70 | .75 | 49.60 | 98.51 | 1.49 | 98.31 | 99.80 | 10.23 | .15 | .06 |
| +425 | 500.00 | 48.70 | 2.68 | 48.70 | 94.78 | 5.22 | 94.78 | 100.00 | 16.05 | .84 | .31 |
| +600 | 710.00 | 49.00 | 2.30 | 48.70 | 95.52 | 4.48 | 94.93 | 99.39 | 17.99 | .81 | .30 |
| +850 | 1000.00 | 46.50 | 7.85 | 45.70 | 85.56 | 14.44 | 84.08 | 98.28 | 21.41 | 3.09 | 1.14 |
| +1180 | 1400.00 | 48.70 | 2.68 | 48.70 | 94.78 | 5.22 | 94.78 | 100.00 | 16.04 | .84 | .31 |
| +1700 | 2000.00 | 49.60 | 2.13 | 48.30 | 95.88 | 4.12 | 93.37 | 97.38 | 5.47 | .23 | .08 |
| +2360 | 2800.00 | 50.10 | 1.71 | 48.20 | 96.70 | 3.30 | 93.03 | 96.21 | .73 | .02 | .01 |
| +3350 | 4000.00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| | | | | | | | | | | 6.19 | 2.29 |

PCA MODAL MINERALOGY JUNE 1986

ROUGHER FLOTATION FEED (NO REGRIND MATERIAL) 5099

SYLVITE AREA %

SAMPLE MILL WT= 1.00

| FRACTION | FOR PLOTS | HALITE | SYLVITE | WT FACT. | WEIGHTED SYLVITE AREA % | |
|---|---|---|---|---|---|---|
| -38 | 32.00 | 59.30 | 40.70 | .14 | .06 | .06 |
| +38 | 45.00 | 57.50 | 42.50 | .48 | .20 | .20 |
| +53 | 63.00 | 64.00 | 36.00 | .42 | .15 | .15 |
| +75 | 106.00 | 83.50 | 16.50 | 2.01 | .33 | .33 |
| +150 | 180.00 | 63.50 | 36.50 | 1.87 | .68 | .68 |
| +212 | 250.00 | 63.40 | 36.60 | 3.00 | 1.10 | 1.10 |
| +300 | 355.00 | 55.40 | 44.60 | 5.79 | 2.58 | 2.58 |
| +425 | 500.00 | 62.60 | 37.40 | 9.93 | 3.71 | 3.71 |
| +600 | 710.00 | 62.10 | 37.90 | 12.76 | 4.84 | 4.84 |
| +850 | 1000.00 | 63.00 | 37.00 | 16.95 | 6.27 | 6.27 |
| +1180 | 1400.00 | 74.80 | 25.20 | 23.37 | 5.89 | 5.89 |
| +1700 | 2000.00 | 76.10 | 23.90 | 17.91 | 4.28 | 4.28 |
| +2360 | 2800.00 | 73.80 | 26.20 | 5.23 | 1.37 | 1.37 |
| +3350 | 4000.00 | 52.70 | 47.30 | .14 | .07 | .07 |
| | | | | | 31.53 | 31.53 |

PCA MODAL MINERALOGY JUNE 1986

ROUGHER TAILS SCREEN OVERSIZE 5100

| SYLVITE AREA % | | | | WT. | | MILL WT= | .35 |
|---|---|---|---|---|---|---|---|
| FRACTION | FOR PLOTS | HALITE | SYLVITE | FRACT. | WEIGHTED | SYLVITE AREA % | |
| -38 | 32.00 | 46.90 | 53.10 | .05 | .03 | .01 | |
| +38 | 45.00 | 59.80 | 40.20 | .14 | .06 | .02 | |
| +53 | 63.00 | 73.40 | 26.60 | .08 | .02 | .01 | |
| +75 | 106.00 | 64.20 | 35.80 | .40 | .14 | .05 | |
| +150 | 180.00 | 89.30 | 10.70 | .49 | .05 | .02 | |
| +212 | 250.00 | 90.90 | 9.10 | .93 | .08 | .03 | |
| +300 | 355.00 | 92.90 | 7.10 | 2.23 | .16 | .06 | |
| +425 | 500.00 | 96.70 | 3.30 | 5.41 | .18 | .06 | |
| +600 | 710.00 | 92.50 | 7.50 | 9.21 | .69 | .24 | |
| +850 | 1000.00 | 78.90 | 21.10 | 21.70 | 4.58 | 1.60 | |
| +1180 | 1400.00 | 75.00 | 25.00 | 33.83 | 8.46 | 2.96 | |
| +1700 | 2000.00 | 74.30 | 25.70 | 23.28 | 5.98 | 2.09 | |
| +2360 | 2800.00 | 83.80 | 16.20 | 2.07 | .34 | .12 | |
| +3350 | 4000.00 | 73.20 | 26.80 | .18 | .05 | .02 | |
| | | | | | 20.81 | 7.29 | |

PCA MODAL MINERALOGY JUNE 1986

ROUGHER FLOTATION CONCENTRATE 5101

SYLVITE AREA %

| FRACTION | FOR PLOTS | HALITE | SYLVITE | WT. FRACT. | WEIGHTED SYLVITE AREA % | |
|---|---|---|---|---|---|---|
| -38 | 32.00 | 35.40 | 64.60 | .29 | .19 | .06 |
| +38 | 45.00 | 40.20 | 59.80 | 2.14 | 1.28 | .38 |
| +53 | 63.00 | 36.00 | 64.00 | 1.53 | .98 | .29 |
| +75 | 106.00 | 32.10 | 67.90 | 4.07 | 2.76 | .83 |
| +150 | 180.00 | 19.50 | 80.50 | 5.08 | 4.09 | 1.23 |
| +212 | 250.00 | 16.10 | 83.90 | 7.17 | 6.02 | 1.80 |
| +300 | 355.00 | 14.60 | 85.40 | 11.05 | 9.44 | 2.83 |
| +425 | 500.00 | 15.10 | 84.90 | 15.82 | 13.43 | 4.03 |
| +600 | 710.00 | 12.50 | 87.50 | 16.40 | 14.35 | 4.31 |
| +850 | 1000.00 | 15.60 | 84.40 | 16.79 | 14.17 | 4.25 |
| +1180 | 1400.00 | 18.10 | 81.90 | 11.97 | 9.80 | 2.94 |
| +1700 | 2000.00 | 19.70 | 80.30 | 6.80 | 5.46 | 1.64 |
| +2360 | 2800.00 | 28.60 | 71.40 | .84 | .60 | .18 |
| +3350 | 4000.00 | .00 | | | | .00 |
| | | | | | 82.57 | 24.77 |

MILL WT= .30

PCA MODAL MINERALOGY JUNE 1986

ROUGHER FLOTATION TAILS 5102

SYLVITE AREA % MILL WT= .70

| FRACTION | FOR PLOTS | HALITE | SYLVITE | WT. FACT. | WEIGHTED | SYLVITE AREA % |
|---|---|---|---|---|---|---|
| -38 | 32.00 | 64.60 | 35.40 | .10 | .04 | .02 |
| +38 | 45.00 | 72.20 | 27.80 | .31 | .09 | .06 |
| +53 | 63.00 | 79.90 | 20.10 | .30 | .06 | .04 |
| +75 | 106.00 | 89.70 | 10.30 | 1.61 | .17 | .12 |
| +150 | 180.00 | 92.60 | 7.40 | 1.66 | .12 | .09 |
| +212 | 250.00 | 96.70 | 3.30 | 2.98 | .10 | .07 |
| +300 | 355.00 | 95.20 | 4.80 | 5.32 | .26 | .18 |
| +425 | 500.00 | 96.70 | 3.30 | 9.31 | .31 | .22 |
| +600 | 710.00 | 90.10 | 9.90 | 13.34 | 1.32 | .92 |
| +850 | 1000.00 | 86.40 | 13.60 | 21.37 | 2.91 | 2.03 |
| +1180 | 1400.00 | 83.60 | 16.40 | 22.88 | 3.75 | 2.63 |
| +1700 | 2000.00 | 71.90 | 28.10 | 17.19 | 4.83 | 3.38 |
| +2360 | 2800.00 | 74.20 | 25.80 | 3.53 | .91 | .64 |
| +3350 | 4000.00 | .00 | | | | .00 |
| | | | | | 14.85 | 10.40 |

Liberation data for PCA samples collected June 1986.

COARSE CONCENTRATE (SLURRY TANK) RPC #5093

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 3.5e5 | 5.2e5 | 8.7e5 | 9.6e5 | .01 | .01 | 8.79 | .10 | 100.00 | 32 | 99.90 |
| +38 | 2.4e5 | 5.6e6 | 5.8e6 | 6.0e6 | .01 | .01 | 8.78 | .11 | 99.90 | 45 | 99.80 |
| +53 | 4.0e5 | 5.5e6 | 5.9e6 | 6.1e6 | .03 | .03 | 8.77 | .33 | 99.79 | 63 | 99.49 |
| +75 | 1.1e6 | 1.3e7 | 1.4e7 | 1.5e7 | .13 | .13 | 8.74 | 1.44 | 99.45 | 106 | 99.19 |
| +150 | 8e6 | 3.5e7 | 4.3e7 | 4.5e7 | .18 | .17 | 8.62 | 1.94 | 98.02 | 180 | 97.58 |
| +212 | 2.3e6 | 1.2e8 | 1.2e8 | 1.2e8 | .40 | .40 | 8.45 | 4.52 | 96.08 | 250 | 95.92 |
| +300 | 2.8e6 | 1.3e8 | 1.3e8 | 1.3e8 | .84 | .83 | 8.05 | 9.47 | 91.55 | 355 | 92.94 |
| +425 | 1.8e6 | 1.1e8 | 1.1e8 | 1.1e8 | 1.77 | 1.77 | 7.22 | 20.10 | 82.09 | 500 | 87.62 |
| +600 | 5.3e5 | 4.6e7 | 4.6e7 | 4.7e7 | 2.73 | 2.69 | 5.45 | 30.62 | 61.98 | 710 | 78.31 |
| +850 | 1.1e6 | 1.0e8 | 1.0e8 | 1.1e8 | 1.98 | 1.96 | 2.76 | 22.34 | 31.37 | 1000 | 64.97 |
| +1180 | 3.7e6 | 7.4e7 | 7.8e7 | 8.0e7 | .70 | .69 | .79 | 7.79 | 9.03 | 1400 | 43.60 |
| +1700 | 6.0e7 | 6.4e7 | 1.2e8 | 1.4e8 | .11 | .10 | .11 | 1.11 | 1.23 | 2000 | 20.72 |
| +2360 | 5.7e7 | 1.6e7 | 7.3e7 | 1.3e8 | .02 | .01 | .01 | .13 | .13 | 2800 | 3.53 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 | .00 |
| | | | | | 8.91 | 8.79 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGROUND ROUGHER TAILS RPC #5097

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 1.4e5 | 1.6e6 | 1.7e6 | 1.9e6 | .01 | .01 | 3.93 | .22 | 100.00 | 32 | 1.40 |
| +38 | 7.1e5 | 1.1e6 | 1.9e6 | 2.3e6 | .03 | .02 | 3.92 | .62 | 99.78 | 45 | 1.30 |
| +53 | 6.8e5 | 9.1e5 | 1.6e6 | 2.0e6 | .02 | .02 | 3.90 | .40 | 99.16 | 63 | 1.20 |
| +75 | 4.1e5 | 2.7e6 | 3.1e6 | 4.2e6 | .13 | .10 | 3.88 | 2.46 | 98.76 | 106 | 1.10 |
| +150 | 1.2e6 | 5.4e6 | 6.6e6 | 9.1e6 | .14 | .10 | 3.79 | 2.57 | 96.30 | 180 | 1.00 |
| +212 | 3.2e6 | 1.4e7 | 1.7e7 | 2.5e7 | .26 | .17 | 3.69 | 4.45 | 93.73 | 250 | .90 |
| +300 | 3.1e6 | 1.1e7 | 1.4e7 | 2.1e7 | .44 | .30 | 3.51 | 7.57 | 89.28 | 355 | .80 |
| +425 | 2.0e6 | 1.1e7 | 1.3e7 | 1.7e7 | .66 | .49 | 3.21 | 12.40 | 81.71 | 500 | .70 |
| +600 | 3.2e6 | 9.3e6 | 1.2e7 | 1.8e7 | .83 | .58 | 2.73 | 14.71 | 69.32 | 710 | .60 |
| +850 | 2.9e6 | 1.2e7 | 1.5e7 | 2.5e7 | 1.56 | .94 | 2.15 | 23.85 | 54.60 | 1000 | .50 |
| +1180 | 1.9e6 | 7.7e6 | 9.6e6 | 2.0e7 | 1.81 | .88 | 1.21 | 22.42 | 30.75 | 1400 | .40 |
| +1700 | 3.0e6 | 6.9e6 | 9.9e6 | 2.7e7 | .85 | .31 | .33 | 7.94 | 8.33 | 2000 | .30 |
| +2360 | 2.3e6 | 2.2e6 | 4.5e6 | 3.6e7 | .12 | .02 | .02 | .39 | .39 | 2800 | .20 |
| +3350 | 0 | 1.5e6 | 1.5e6 | 3.5e6 | .00 | .00 | .00 | .00 | .00 | 4000 | .10 |
| | | | | | 6.86 | 3.93 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

MIXED TAILINGS RPC #5098

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 5.2e4 | 3.5e4 | 8.7e4 | 1.4e5 | .01 | .01 | 1.18 | .52 | 100.00 | 32 | 1.40 |
| +38 | 1.2e5 | 2.0e5 | 3.2e5 | 5.4e5 | .01 | .01 | 1.18 | .50 | 99.48 | 45 | 1.30 |
| +53 | 4.0e4 | 8.4e4 | 1.2e5 | 2.7e5 | .01 | .00 | 1.17 | .39 | 98.98 | 63 | 1.20 |
| +75 | 2.1e4 | 8.7e4 | 1.1e5 | 5.5e4 | .01 | .02 | 1.17 | 1.66 | 98.59 | 106 | 1.10 |
| +150 | 1.1e4 | 4.0e5 | 4.1e5 | 7e5 | .02 | .01 | 1.15 | 1.00 | 96.93 | 180 | 1.00 |
| +212 | 1.0e5 | 5.3e5 | 6.3e5 | 1.9e6 | .03 | .01 | 1.13 | .82 | 95.93 | 250 | .90 |
| +300 | 1.7e4 | 3.7e5 | 3.9e5 | 1.7e6 | .06 | .01 | 1.12 | 1.12 | 95.11 | 355 | .80 |
| +425 | 3.4e5 | 2.3e5 | 5.7e5 | 1.6e6 | .31 | .11 | 1.11 | 9.61 | 93.98 | 500 | .70 |
| +600 | 4.9e5 | 3.8e6 | 4.3e6 | 5.8e6 | .30 | .22 | 1.00 | 18.84 | 84.37 | 710 | .60 |
| +850 | 1.0e6 | 1.4e6 | 2.4e6 | 4.8e6 | 1.14 | .58 | .77 | 49.03 | 65.53 | 1000 | .50 |
| +1180 | 1.6e6 | 6.8e6 | 8.3e6 | 1.3e7 | .31 | .19 | .20 | 16.45 | 16.50 | 1400 | .40 |
| +1700 | 0 | 0 | 0 | 5.0e6 | .08 | .00 | .00 | .00 | .06 | 2000 | .30 |
| +2360 | 0 | 2.9e5 | 2.9e5 | 4.3e6 | .01 | .00 | .00 | .06 | .06 | 2800 | .20 |
| +3350 | | | 0 | | .00 | .00 | .00 | .00 | .00 | 4000 | .10 |
| | | | | | 2.30 | 1.18 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION FEED (NO REGRIND MATERIAL) 5099

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. | CUM. WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 2.4e5 | 6.5e4 | 3.1e5 | 4.7e5 | .06 | .04 | 13.28 | .29 | 100.00 | 32 | 100.00 | 31.53 |
| +38 | 4.1e6 | 2.1e4 | 4.1e6 | 6.1e6 | .20 | .13 | 13.24 | 1.01 | 99.71 | 45 | 99.86 | 31.47 |
| +53 | 5.6e6 | 2.5e4 | 5.6e6 | 1.2e7 | .15 | .07 | 13.10 | .54 | 98.70 | 63 | 99.38 | 31.27 |
| +75 | 2.3e6 | 5.2e5 | 2.9e6 | 6.6e6 | .33 | .14 | 13.03 | 1.07 | 98.16 | 106 | 98.96 | 31.12 |
| +150 | 1.4e7 | 1.2e7 | 2.6e7 | 4.1e7 | .68 | .43 | 12.89 | 3.27 | 97.09 | 180 | 96.95 | 30.79 |
| +212 | 1.8e7 | 3.1e6 | 2.1e7 | 5e7 | 1.10 | .46 | 12.46 | 3.49 | 93.82 | 250 | 95.08 | 30.11 |
| +300 | 8.9e6 | 2.3e7 | 3.2e7 | 5.9e7 | 2.58 | 1.40 | 11.99 | 10.57 | 90.32 | 355 | 92.08 | 29.01 |
| +425 | 1.8e7 | 7.9e6 | 2.6e7 | 4.8e7 | 3.71 | 2.00 | 10.59 | 15.03 | 79.75 | 500 | 86.29 | 26.43 |
| +600 | 2.1e7 | 1.8e7 | 4.0e7 | 7.3e7 | 4.84 | 2.62 | 8.59 | 19.70 | 64.72 | 710 | 76.36 | 22.72 |
| +850 | 1.9e7 | 8.3e6 | 2.7e7 | 8.2e7 | 6.27 | 2.05 | 5.98 | 15.40 | 45.02 | 1000 | 63.60 | 17.88 |
| +1180 | 7.8e6 | 1.4e7 | 2.2e7 | 5.4e7 | 5.89 | 2.34 | 3.93 | 17.60 | 29.62 | 1400 | 46.65 | 11.61 |
| +1700 | 1.2e7 | 7.3e6 | 1.9e7 | 5.8e7 | 4.28 | 1.42 | 1.60 | 10.66 | 12.02 | 2000 | 23.28 | 5.72 |
| +2360 | 3.6e6 | 9.1e5 | 4.5e6 | 3.9e7 | 1.37 | .16 | .18 | 1.20 | 1.36 | 2800 | 5.37 | 1.44 |
| +3350 | 3.2e6 | 3.4e5 | 3.6e6 | 1.2e7 | .07 | .02 | .02 | .16 | .16 | 4000 | .14 | .07 |
| | | | | | 31.53 | 13.28 | | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER TAILS SCREEN OVERSIZE 5100

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 4.3e6 | 2.2e5 | 4.5e6 | 7.2e6 | .01 | .01 | 2.67 | .23 | 100.00 | 32 | 100.00 |
| +38 | 3.6e6 | 9.4e3 | 3.6e6 | 9.5e6 | .02 | .01 | 2.66 | .29 | 99.77 | 45 | 99.95 |
| +53 | 3.6e6 | 9.4e3 | 3.6e6 | 9.5e6 | .01 | .00 | 2.65 | .14 | 99.48 | 63 | 99.81 |
| +75 | 6.2e6 | 1.6e6 | 7.8e6 | 1.6e7 | .05 | .03 | 2.65 | .94 | 99.33 | 106 | 99.73 |
| +150 | 5.9e6 | 8.6e5 | 6.8e6 | 1.5e7 | .02 | .01 | 2.62 | .34 | 98.39 | 180 | 99.33 |
| +212 | 3.0e6 | 9.9e4 | 3.1e6 | 1.1e7 | .03 | .01 | 2.62 | .33 | 98.05 | 250 | 98.84 |
| +300 | 1.9e6 | 1.1e6 | 3.0e6 | 9.8e6 | .06 | .02 | 2.61 | .70 | 97.72 | 355 | 97.91 |
| +425 | 1.2e5 | 0 | 1.2e5 | 4.3e5 | .06 | .02 | 2.59 | .63 | 97.03 | 500 | 95.68 |
| +600 | 3.6e6 | 1.2e6 | 4.8e6 | 1.5e7 | .24 | .08 | 2.57 | 2.87 | 96.40 | 710 | 90.27 |
| +850 | 1.1e7 | 5.3e6 | 1.6e7 | 5.5e7 | 1.60 | .48 | 2.49 | 18.12 | 93.52 | 1000 | 81.06 |
| +1180 | 1.9e7 | 9.3e6 | 2.8e7 | 6.5e7 | 2.96 | 1.28 | 2.01 | 47.89 | 75.41 | 1400 | 59.36 |
| +1700 | 5.3e6 | 1.3e7 | 1.8e7 | 5.4e7 | 2.09 | .70 | .73 | 26.38 | 27.52 | 2000 | 25.53 |
| +2360 | 2.3e6 | 4.0e6 | 6.3e6 | 3.2e7 | .12 | .02 | .03 | .88 | 1.14 | 2800 | 2.25 |
| +3350 | 1.5e7 | 4.5e5 | 1.6e7 | 4.5e7 | .02 | .01 | .01 | .26 | .26 | 4000 | .18 |
| | | | | | 7.29 | 2.67 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION CONCENTRATE 5101

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. | CUM. WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 1.2e5 | 4.8e5 | 6.1e5 | 6.4e5 | .06 | .06 | 16.10 | .36 | 100.00 | 32 | 99.95 | 24.77 |
| +38 | 1.1e6 | 0 | 1.1e6 | 4.7e6 | .38 | .09 | 16.05 | .55 | 99.64 | 45 | 99.66 | 24.71 |
| +53 | 1.1e7 | 1.1e4 | 1.1e7 | 2.1e7 | .29 | .15 | 15.96 | .95 | 99.10 | 63 | 97.52 | 24.33 |
| +75 | 1.5e7 | 2.7e6 | 1.7e7 | 2.7e7 | .83 | .53 | 15.81 | 3.31 | 98.15 | 106 | 95.99 | 24.04 |
| +150 | 3.3e7 | 3.5e7 | 6.8e7 | 9.2e7 | 1.23 | .91 | 15.27 | 5.64 | 94.84 | 180 | 91.92 | 23.21 |
| +212 | 3.6e7 | 5.1e7 | 8.7e7 | 1.1e8 | 1.80 | 1.40 | 14.36 | 8.71 | 89.19 | 250 | 86.84 | 21.98 |
| +300 | 2.9e7 | 5.5e7 | 8.4e7 | 1.1e8 | 2.83 | 2.21 | 12.96 | 13.71 | 80.48 | 355 | 79.67 | 20.18 |
| +425 | 5.1e7 | 9.8e6 | 6.1e7 | 1e8 | 4.03 | 2.47 | 10.75 | 15.33 | 66.77 | 500 | 68.62 | 17.35 |
| +600 | 7.1e7 | 5.9e7 | 1.3e8 | 1.7e8 | 4.31 | 3.26 | 8.28 | 20.27 | 51.44 | 710 | 52.80 | 13.32 |
| +850 | 5.9e7 | 4.0e7 | 9.9e7 | 1.7e8 | 4.25 | 2.51 | 5.02 | 15.61 | 31.18 | 1000 | 36.40 | 9.01 |
| +1180 | 4.2e7 | 5.5e7 | 9.7e7 | 1.4e8 | 2.94 | 2.03 | 2.51 | 12.59 | 15.56 | 1400 | 19.61 | 4.76 |
| +1700 | 1.4e7 | 1.4e7 | 2.7e7 | 9.4e7 | 1.64 | .48 | .48 | 2.97 | 2.98 | 2000 | 7.64 | 1.82 |
| +2360 | 4.1e5 | 0 | 4.1e5 | 7.6e7 | .18 | .00 | .00 | .01 | .01 | 2800 | .84 | .18 |
| | | | | 0 | 24.77 | 16.10 | .00 | | .00 | 4000 | .00 | |
| | | | | | | | | 100.00 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION TAILS 5102

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 7.5e4 | 2.8e5 | 3.6e5 | 3.8e5 | .02 | .02 | 4.10 | .45 | 100.00 | 32 | 99.90 |
| +38 | 1.0e6 | 2.0e3 | 1.0e6 | 2.7e6 | .06 | .02 | 4.08 | .55 | 99.55 | 45 | 99.80 |
| +53 | 1.5e6 | 0 | 1.5e6 | 5.9e6 | .04 | .01 | 4.06 | .25 | 98.99 | 63 | 99.49 |
| +75 | 1.0e6 | 1.6e5 | 1.2e6 | 4.1e6 | .12 | .03 | 4.05 | .85 | 98.74 | 106 | 99.19 |
| +150 | 1.7e6 | 1.2e6 | 2.8e6 | 8.9e6 | .09 | .03 | 4.01 | .70 | 97.89 | 180 | 97.58 |
| +212 | 2.1e6 | 7.1e4 | 2.2e6 | 4.1e6 | .07 | .04 | 3.98 | .90 | 97.20 | 250 | 95.92 |
| +300 | 1.1e6 | 6.3e5 | 1.7e6 | 6.4e6 | .18 | .05 | 3.95 | 1.19 | 96.29 | 355 | 92.94 |
| +425 | 1.5e6 | 0 | 1.5e6 | 4.3e6 | .22 | .08 | 3.90 | 1.90 | 95.10 | 500 | 87.62 |
| +600 | 3.6e6 | 3.6e5 | 3.9e6 | 2.0e7 | .92 | .18 | 3.82 | 4.44 | 93.20 | 710 | 78.31 |
| +850 | 9.2e6 | 1.1e6 | 1.0e7 | 3.1e7 | 2.03 | .69 | 3.64 | 16.74 | 88.76 | 1000 | 64.97 |
| +1180 | 1.3e7 | 0 | 1.3e7 | 3.4e7 | 2.63 | 1.04 | 2.95 | 25.28 | 72.02 | 1400 | 43.60 |
| +1700 | 2.3e7 | 1.2e7 | 3.5e7 | 6.8e7 | 3.38 | 1.72 | 1.92 | 42.07 | 46.74 | 2000 | 20.72 |
| +2360 | 1.2e6 | 1.1e7 | 1.2e7 | 4.1e7 | .64 | .19 | .19 | 4.67 | 4.67 | 2800 | 3.53 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 | .00 |
| | | | | | 10.40 | 4.10 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

9.

FINAL TAILINGS RPC #5104 (SCREEN UNDERSIZE)

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -38 | 3.4e4 | 5.4e4 | 8.8e4 | 1.5e5 | .00 | .00 | 3.71 | .02 | 100.00 | 32 | 1.40 |
| +38 | 4.0e4 | 1.1e5 | 1.5e5 | 2.5e5 | .00 | .00 | 3.71 | .02 | 99.98 | 45 | 1.30 |
| +53 | 3.8e4 | 5.1e4 | 8.9e4 | 2.2e5 | .00 | .00 | 3.70 | .01 | 99.97 | 63 | 1.20 |
| +75 | 9.4e3 | 9.7e4 | 1.1e5 | 2.9e5 | .01 | .00 | 3.70 | .10 | 99.96 | 106 | 1.10 |
| +150 | 2.1e5 | 2.3e5 | 4.3e5 | 6.8e5 | .07 | .04 | 3.70 | 1.20 | 99.86 | 180 | 1.00 |
| +212 | 2.7e5 | 2.1e5 | 4.8e5 | 1e6 | .28 | .13 | 3.66 | 3.61 | 98.66 | 250 | .90 |
| +300 | 3.4e5 | 4.3e5 | 7.7e5 | 1.3e6 | .81 | .49 | 3.52 | 13.20 | 95.04 | 355 | .80 |
| +425 | 1.6e5 | 5.7e5 | 7.3e5 | 1.3e6 | 1.33 | .72 | 3.03 | 19.52 | 81.84 | 500 | .70 |
| +600 | 6.0e5 | 1.1e6 | 1.7e6 | 3.9e6 | 1.64 | .71 | 2.31 | 19.14 | 62.32 | 710 | .60 |
| +850 | 2.4e6 | 7.6e6 | 1e7 | 1.6e7 | 1.66 | 1.07 | 1.60 | 28.90 | 43.18 | 1000 | .50 |
| +1180 | 9.5e5 | 1.6e6 | 2.5e6 | 7.7e6 | 1.54 | .50 | .53 | 13.45 | 14.28 | 1400 | .40 |
| +1700 | 3e4 | 2.3e5 | 2.6e5 | 3.4e6 | .41 | .03 | .03 | .84 | .84 | 2000 | .30 |
| +2360 | 0 | 0 | 0 | 2.6e6 | .00 | .00 | .00 | .00 | .00 | 2800 | .20 |
| +3350 | | | 0 | | .00 | .00 | .00 | .00 | .00 | 4000 | .10 |
| | | | | | 7.75 | 3.71 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

# APPENDIX A-6
# CHEMICAL COMPOSITION OF MILL SAMPLES COLLECTED
# AUGUST 27 AND 28, 1987

TABLE CHEMICAL ANALYSIS OF PCA MILL SAMPLES COLLECTED AUG. 27, 1987

| DESCRIPTION | MILL PRODUCT | ROUGH FLOT FEED | ROUGH FLOT TAILS | ROUGH FLOT CONC | BALL MILL FEED | BALL MILL DIS | REGR FLOT CONC | REG FLOT TAILS | SLIMES THICH U/F |
|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5131 | 5132 | 5133 | 5134 | 5135 | 5136 | 5137 | 5138 | 5139 |
| WT% | | | | | | | | | |
| K | 19.87 | 18.15 | 7.58 | 45.62 | 10.18 | 10.45 | 41.77 | 5.62 | NOT |
| CA | .16 | .21 | .14 | .13 | .02 | nd | .13 | .17 | ANAL |
| NA | 22.40 | 23.16 | 31.62 | 4.47 | 29.91 | 29.78 | 5.09 | 33.60 | |
| CL | 50.84 | 52.28 | 55.76 | 47.00 | 55.89 | 55.82 | 47.66 | 56.98 | |
| SO4 | .38 | .37 | .37 | .23 | .39 | .36 | .31 | .36 | |
| INSOLUBLES | 3.18 | 1.54 | 1.07 | 1.38 | .89 | 1.04 | 1.57 | .87 | |
| TOTAL | 96.82 | 95.70 | 96.53 | 98.83 | 97.27 | 97.45 | 96.52 | 97.59 | |
| NORM | | | | | | | | | |
| SYLVITE K | 37.89 | 34.60 | 14.44 | 86.98 | 19.40 | 19.92 | 79.63 | 10.71 | |
| HALITE NA | 56.93 | 58.86 | 80.38 | 11.36 | 76.02 | 75.70 | 12.93 | 85.40 | |
| ANAL. CL | 50.84 | 52.28 | 55.76 | 47.00 | 55.89 | 55.82 | 47.66 | 56.98 | |
| CAL. CL | 52.55 | 52.16 | 55.63 | 48.26 | 55.34 | 55.40 | 45.71 | 56.90 | |
| ANHYDRITE | .54 | .71 | .48 | .44 | .07 | .00 | .44 | .58 | |
| CAL SO4 | .38 | .50 | .34 | .31 | .05 | .00 | .31 | .41 | |
| INSOLUBLES | 3.18 | 1.54 | 1.07 | 1.38 | .89 | 1.04 | 1.57 | .87 | |
| NORM TOTAL | 98.54 | 95.71 | 96.37 | 100.17 | 96.38 | 96.67 | 94.57 | 97.55 | |

RESEARCH AND PRODUCTIVITY COUNCIL

TABLE CHEMICAL ANALYSIS OF PCA MILL SAMPLES COLLECTED AUG. 28, 1987

| DESCRIPTION | REGR FLOT CONC | ROUGH FLOT TAILS | REGR FLOT TAILS | BALL MILL DIS | ROUGH FLOT FEED | BALL MILL FEED | ROUGH FLOT CONC |
|---|---|---|---|---|---|---|---|
| SAMPLE | 5140 | 5141 | 5142 | 5143 | 5144 | 5145 | 5146 |
| WT% | | | | | | | |
| K | 37.97 | 7.24 | 7.88 | 11.05 | 19.14 | 11.49 | 39.36 |
| CA | .17 | .15 | .11 | .14 | .15 | .18 | .11 |
| NA | 8.80 | 32.08 | 27.62 | 27.26 | 20.49 | 27.78 | 6.81 |
| CL | 50.78 | 55.65 | 50.29 | 54.09 | 50.17 | 52.88 | 48.06 |
| SO4 | .26 | .34 | .37 | .34 | .34 | .35 | .23 |
| INSOLUBLES | 1.20 | .87 | .90 | .90 | 1.34 | .84 | 1.35 |
| TOTAL | 99.18 | 96.32 | 87.17 | 93.77 | 91.63 | 93.52 | 95.92 |
| NORM | | | | | | | |
| SYLVITE K | 72.40 | 13.80 | 15.02 | 21.06 | 36.49 | 21.90 | 75.05 |
| HALITE NA | 22.36 | 81.54 | 70.21 | 69.30 | 52.07 | 70.62 | 17.30 |
| ANAL. CL | 50.78 | 55.65 | 50.29 | 54.09 | 50.17 | 52.88 | 48.06 |
| CAL. CL | 47.99 | 56.03 | 49.74 | 52.05 | 48.94 | 53.25 | 46.18 |
| ANHYDRITE | .58 | .51 | .37 | .48 | .51 | .61 | .37 |
| CAL SO4 | .41 | .36 | .26 | .34 | .36 | .43 | .26 |
| INSOLUBLES | 1.20 | .87 | .90 | .90 | 1.34 | .84 | 1.35 |
| NORM TOTAL | 96.53 | 96.72 | 86.51 | 91.73 | 90.42 | 93.97 | 94.07 |

RESEARCH AND PRODUCTIVITY COUNCIL

# APPENDIX A-7
# SIEVE ANALYSIS, MODAL MINERALOGY AND LIBERATION DATA
# AUGUST 27 AND 28, 1987

TABLE SIEVE ANLYSIS FOR PCA SAMPLES COLLECTED AUG. 27,1987

| NORMALIZED | PCA MILL PROD | ROUGH FLOT FEED | ROUGH FLOT TAIL | ROUGH FLOT CONC | BALL MILL FEED | BALL MILL DIS | REGR FLOT CONC | REGR FLOT TAIL |
|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5131 | 5132 | 5133 | 5134 | 5135 | 5136 | 5137 | 5138 |
| -37 NM | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| +37 | .16 | 2.74 | 2.85 | 4.57 | .01 | .47 | 4.80 | .37 |
| +75 | 2.48 | 13.60 | 12.71 | 12.69 | .79 | 7.76 | 28.94 | 4.47 |
| +212 | 2.49 | 20.39 | 18.68 | 24.32 | 3.26 | 24.62 | 35.49 | 29.54 |
| +425 | 6.74 | 15.00 | 12.61 | 22.40 | 4.46 | 21.68 | 20.08 | 19.67 |
| +600 | 7.40 | 13.43 | 13.09 | 17.81 | 10.90 | 17.40 | 8.74 | 18.16 |
| +850 | 2.56 | 5.84 | 6.29 | 6.63 | 9.93 | 7.14 | .52 | 7.60 |
| +1.00MM | 2.78 | 5.34 | 6.18 | 5.18 | 12.79 | 5.97 | .40 | 6.65 |
| +1.18 | 3.53 | 5.56 | 6.64 | 3.84 | 11.99 | 5.32 | .14 | 5.99 |
| +1.40 | 3.89 | 5.37 | 6.62 | 1.65 | 14.62 | 4.05 | .24 | 3.78 |
| +1.70 | 2.38 | 2.99 | 3.90 | .53 | 8.69 | 1.91 | .19 | 1.63 |
| +2.00 | 2.92 | 3.86 | 4.42 | .29 | 9.99 | 1.88 | .28 | 1.25 |
| +2.36 | 2.35 | 2.59 | 2.68 | .08 | 6.10 | 1.00 | .18 | .53 |
| +2.80 | 2.39 | 1.76 | 1.71 | .00 | 3.70 | .42 | .01 | .23 |
| +3.35 | 57.92 | 1.52 | 1.61 | .00 | 2.76 | .38 | .01 | .13 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

TABLE SIEVE ANLYSIS FOR PCA SAMPLES COLLECTED AUG. 28,1987

| NORMALIZED SAMPLE | REGR FLOT CONC 5140 | ROUGH FLOT TAIL 5141 | ROUGH FLOT TAIL 5142 | BALL MILL DIS 5143 | ROUGH FLOT FEED 5144 | BALL MILL FEED 5145 | ROUGH FLOT CONC 5146 |
|---|---|---|---|---|---|---|---|
| -37 NM | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| +37 | 1.33 | .20 | .44 | .10 | .17 | .08 | 2.24 |
| +75 | 16.00 | 3.83 | 5.77 | 1.14 | 1.83 | .59 | 10.87 |
| +212 | 34.58 | 13.09 | 15.22 | 18.60 | 7.62 | 3.33 | 21.94 |
| +425 | 11.60 | 12.40 | 11.43 | 12.74 | 9.34 | 5.34 | 20.97 |
| +600 | 18.53 | 17.51 | 15.93 | 20.06 | 14.80 | 9.92 | 22.05 |
| +850 | 5.33 | 10.09 | 9.71 | 10.65 | 9.35 | 10.05 | 7.79 |
| +1.00MM | 2.53 | 9.72 | 8.39 | 9.10 | 8.70 | 12.23 | 5.33 |
| +1.18 | 1.43 | 8.77 | 7.60 | 7.66 | 8.80 | 12.27 | 3.08 |
| +1.40 | 1.33 | 8.43 | 9.03 | 8.21 | 10.09 | 16.90 | 1.86 |
| +1.70 | 1.16 | 4.85 | 4.82 | 3.85 | 6.63 | 8.30 | .78 |
| +2.00 | 1.24 | 4.53 | 4.92 | 3.47 | 7.83 | 8.01 | .71 |
| +2.36 | 1.21 | 2.89 | 3.30 | 2.19 | 6.45 | 5.71 | .60 |
| +2.80 | 1.05 | 2.06 | 2.10 | 1.37 | 4.77 | 3.72 | .68 |
| +3.35 | 2.67 | 1.63 | 1.33 | .86 | 3.62 | 3.56 | 1.10 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

PCA MODAL MINERALOGY AUG. 27,1987

COARSE ROUGHER FEED RPC #5132

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WT. = 1.00 WEIGHTED | SYLVITE AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 29.40 | 41.30 | 29.30 | 41.58 | 58.42 | 41.44 | 99.66 | 2.74 | 1.60 | 1.60 |
| +75 | 126 | 37.00 | 26.10 | 36.90 | 58.64 | 41.36 | 58.48 | 99.73 | 13.60 | 5.63 | 5.63 |
| +212 | 300 | 38.80 | 22.40 | 38.70 | 63.40 | 36.60 | 63.24 | 99.74 | 20.39 | 7.46 | 7.46 |
| +425 | 505 | 37.90 | 24.50 | 37.60 | 60.74 | 39.26 | 60.26 | 99.21 | 15.00 | 5.89 | 5.89 |
| +600 | 714 | 38.10 | 24.10 | 37.80 | 61.25 | 38.75 | 60.77 | 99.21 | 13.43 | 5.20 | 5.20 |
| +850 | 922 | 38.40 | 23.60 | 38.00 | 61.94 | 38.06 | 61.29 | 98.96 | 5.84 | 2.22 | 2.22 |
| +1.00MM | 1086 | 42.90 | 14.60 | 42.50 | 74.61 | 25.39 | 73.91 | 99.07 | 5.34 | 1.36 | 1.36 |
| +1.18 | 1285 | 42.30 | 16.20 | 41.60 | 72.31 | 27.69 | 71.11 | 98.35 | 5.56 | 1.54 | 1.54 |
| +1.40 | 1543 | 42.20 | 16.80 | 41.10 | 71.53 | 28.47 | 69.66 | 97.39 | 5.37 | 1.53 | 1.53 |
| +1.70 | 1844 | 41.90 | 16.70 | 41.40 | 71.50 | 28.50 | 70.65 | 98.81 | 2.99 | .85 | .85 |
| +2.00 | 2173 | 43.70 | 13.20 | 43.10 | 76.80 | 23.20 | 75.75 | 98.63 | 3.86 | .90 | .90 |
| +2.36 | 2571 | 44.40 | 11.20 | 44.30 | 79.86 | 20.14 | 79.68 | 99.77 | 2.59 | .52 | .52 |
| +2.80 | 3063 | 42.20 | 15.90 | 41.90 | 72.63 | 27.37 | 72.12 | 99.29 | 1.76 | .48 | .48 |
| +3.35 | 4000 | 39.70 | 21.00 | 39.30 | 65.40 | 34.60 | 64.74 | 98.99 | 1.52 | .53 | .53 |
| | | | | | | | | | 99.99 | 35.71 | 35.71 |

PCA MODAL MINERALOGY AUG. 27,1987

COARSE ROUGHER TAILS #5133

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | S DISSOL. | WT FACT. | MILL WT. WEIGHTED | = SYLVITE | .64 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 43.30 | 13.60 | 43.20 | 76.10 | 23.90 | 75.92 | 99.77 | 2.85 | .68 | .44 | |
| +75 | 126 | 47.60 | 4.91 | 47.50 | 90.65 | 9.35 | 90.46 | 99.79 | 12.71 | 1.19 | .76 | |
| +212 | 300 | 47.60 | 4.93 | 47.50 | 90.61 | 9.39 | 90.42 | 99.79 | 18.68 | 1.75 | 1.12 | |
| +425 | 505 | 47.30 | 5.52 | 47.20 | 89.55 | 10.45 | 89.36 | 99.79 | 12.61 | 1.32 | .84 | |
| +600 | 714 | 48.20 | 3.67 | 48.20 | 92.92 | 7.08 | 92.92 | 100.00 | 13.09 | .93 | .59 | |
| +850 | 922 | 47.30 | 5.59 | 47.20 | 89.43 | 10.57 | 89.24 | 99.79 | 6.29 | .66 | .43 | |
| +1.00MM | 1086 | 47.30 | 5.37 | 47.30 | 89.80 | 10.20 | 89.80 | 100.00 | 6.18 | .63 | .40 | |
| +1.18 | 1285 | 45.10 | 9.88 | 45.00 | 82.03 | 17.97 | 81.85 | 99.78 | 6.64 | 1.19 | .76 | |
| +1.40 | 1543 | 43.20 | 13.70 | 43.10 | 75.92 | 24.08 | 75.75 | 99.77 | 6.62 | 1.59 | 1.02 | |
| +1.70 | 1844 | 45.20 | 10.30 | 44.50 | 81.44 | 18.56 | 80.18 | 98.45 | 3.90 | .72 | .46 | |
| +2.00 | 2173 | 45.80 | 8.96 | 45.20 | 83.64 | 16.36 | 82.54 | 98.69 | 4.42 | .72 | .46 | |
| +2.36 | 2571 | 38.60 | 23.30 | 38.10 | 62.36 | 37.64 | 61.55 | 98.70 | 2.68 | 1.01 | .65 | |
| +2.80 | 3063 | 45.80 | 15.90 | 38.30 | 74.23 | 25.77 | 62.07 | 83.62 | 1.71 | .44 | .28 | |
| +3.35 | 4000 | 43.50 | 13.00 | 43.50 | 76.99 | 23.01 | 76.99 | 100.00 | 1.61 | .37 | .24 | |
| | | | | | | | | | 99.99 | 13.22 | 8.46 | |

PCA MODAL MINERALOGY AUG. 27,1987

COARSE ROUGHER CONCENTRATE #5134

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WT. WEIGHTED | = SYLVITE | .36 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +38 NM | 53 | 16.30 | 68.00 | 15.70 | 19.34 | 80.66 | 18.62 | 96.32 | 4.57 | 3.69 | 1.33 | |
| +75 | 126 | 20.60 | 59.20 | 20.20 | 25.81 | 74.19 | 25.31 | 98.06 | 12.69 | 9.41 | 3.39 | |
| +212 | 300 | 15.00 | 60.50 | 14.50 | 19.87 | 80.13 | 19.21 | 96.67 | 24.32 | 19.49 | 7.02 | |
| +425 | 505 | 7.49 | 85.60 | 6.88 | 8.05 | 91.95 | 7.39 | 91.86 | 22.40 | 20.60 | 7.42 | |
| +600 | 714 | 5.80 | 88.60 | 5.59 | 6.14 | 93.86 | 5.92 | 96.38 | 17.81 | 16.72 | 6.02 | |
| +850 | 922 | 5.59 | 88.90 | 5.48 | 5.92 | 94.08 | 5.80 | 98.03 | 6.63 | 6.24 | 2.25 | |
| +1.00MM | 1086 | 4.60 | 91.00 | 4.44 | 4.81 | 95.19 | 4.64 | 96.52 | 5.18 | 4.93 | 1.78 | |
| +1.18 | 1285 | 4.82 | 90.50 | 4.64 | 5.06 | 94.94 | 4.87 | 96.27 | 3.84 | 3.65 | 1.31 | |
| +1.40 | 1543 | 4.15 | 92.00 | 3.87 | 4.32 | 95.68 | 4.02 | 93.25 | 1.65 | 1.58 | .57 | |
| +1.70 | 1844 | 4.31 | 91.60 | 4.06 | 4.49 | 95.51 | 4.23 | 94.20 | .53 | .51 | .18 | |
| +2.00 | 2173 | 12.30 | 77.50 | 10.20 | 13.70 | 86.30 | 11.36 | 82.93 | .29 | .25 | .09 | |
| +2.36 | 2571 | 28.60 | 44.00 | 27.40 | 39.39 | 60.61 | 37.74 | 95.80 | .08 | .05 | .02 | |
| +2.80 | 3063 | 30.50 | 39.90 | 29.60 | 43.32 | 56.68 | 42.05 | 97.05 | .00 | .00 | .00 | |
| +3.35 | 4000 | 39.80 | 35.10 | 25.20 | 53.14 | 46.86 | 33.64 | 63.32 | .00 | .00 | .00 | |
| | | | | | | | | | 99.99 | 87.10 | 31.36 | |

PCA MODAL MINERALOGY AUG. 27,1987

BALL MILL FEED #5135

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WT. WEIGHTED | = SYLVITE | .42 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 36.30 | 27.70 | 36.00 | 56.72 | 43.28 | 56.25 | 99.17 | .01 | .00 | .00 | |
| +75 | 126 | 45.40 | 9.50 | 45.10 | 82.70 | 17.30 | 82.15 | 99.34 | .79 | .14 | .06 | |
| +212 | 300 | 48.40 | 3.21 | 48.40 | 93.78 | 6.22 | 93.78 | 100.00 | 3.26 | .20 | .08 | |
| +425 | 505 | 49.00 | 2.12 | 48.90 | 95.85 | 4.15 | 95.66 | 99.80 | 4.46 | .18 | .08 | |
| +600 | 714 | 47.30 | 5.42 | 47.30 | 89.72 | 10.28 | 89.72 | 100.00 | 10.90 | 1.12 | .47 | |
| +850 | 922 | 45.90 | 8.17 | 45.90 | 84.89 | 15.11 | 84.89 | 100.00 | 9.93 | 1.50 | .63 | |
| +1.00MM | 1086 | 44.80 | 10.30 | 44.80 | 81.31 | 18.69 | 81.31 | 100.00 | 12.79 | 2.39 | 1.00 | |
| +1.18 | 1285 | 44.70 | 9.85 | 45.50 | 81.94 | 18.06 | 83.41 | 101.79 | 11.99 | 2.17 | .90 | |
| +1.40 | 1543 | 42.90 | 14.30 | 42.80 | 75.00 | 25.00 | 74.83 | 99.77 | 14.62 | 3.66 | 1.52 | |
| +1.70 | 1844 | 43.90 | 12.20 | 43.90 | 78.25 | 21.75 | 78.25 | 100.00 | 8.69 | 1.89 | .79 | |
| +2.00 | 2173 | 40.70 | 18.90 | 40.40 | 68.29 | 31.71 | 67.79 | 99.26 | 9.99 | 3.17 | 1.32 | |
| +2.36 | 2571 | 40.00 | 20.70 | 39.40 | 65.90 | 34.10 | 64.91 | 98.50 | 6.10 | 2.08 | .87 | |
| +2.80 | 3063 | 41.10 | 18.20 | 40.70 | 69.31 | 30.69 | 68.63 | 99.03 | 3.70 | 1.14 | .47 | |
| +3.35 | 4000 | 45.90 | 10.10 | 44.00 | 81.96 | 18.04 | 78.57 | 95.86 | 2.76 | .50 | .21 | |
| | | | | | | | | | 99.99 | 20.13 | 8.40 | |

PCA MODAL MINERALOGY AUG. 27,1987

BALL MILL DISCHARGE #5136

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WT. WEIGHTED | = SYLVITE | .42 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +38 NM | 53 | 43.70 | 12.90 | 43.40 | 77.21 | 22.79 | 76.68 | 99.31 | .47 | .11 | .04 | |
| +75 | 126 | 43.80 | 13.00 | 43.20 | 77.11 | 22.89 | 76.06 | 98.63 | 7.76 | 1.78 | .74 | |
| +212 | 300 | 43.20 | 13.80 | 42.90 | 75.79 | 24.21 | 75.26 | 99.31 | 24.62 | 5.96 | 2.49 | |
| +425 | 505 | 43.10 | 14.00 | 42.90 | 75.48 | 24.52 | 75.13 | 99.54 | 21.68 | 5.32 | 2.22 | |
| +600 | 714 | 43.90 | 12.20 | 43.90 | 78.25 | 21.75 | 78.25 | 100.00 | 17.40 | 3.78 | 1.58 | |
| +850 | 922 | 46.20 | 7.69 | 46.10 | 85.73 | 14.27 | 85.54 | 99.78 | 7.14 | 1.02 | .42 | |
| +1.00MM | 1086 | 44.90 | 10.20 | 44.90 | 81.49 | 18.51 | 81.49 | 100.00 | 5.97 | 1.11 | .46 | |
| +1.18 | 1285 | 47.70 | 5.30 | 47.00 | 90.00 | 10.00 | 88.68 | 98.53 | 5.32 | .53 | .22 | |
| +1.40 | 1543 | 45.30 | 9.92 | 44.70 | 82.04 | 17.96 | 80.95 | 98.68 | 4.05 | .73 | .30 | |
| +1.70 | 1844 | 43.60 | 13.20 | 43.20 | 76.76 | 23.24 | 76.06 | 99.08 | 1.91 | .44 | .19 | |
| +2.00 | 2173 | 42.20 | 15.60 | 42.10 | 73.01 | 26.99 | 72.84 | 99.76 | 1.88 | .51 | .21 | |
| +2.36 | 2571 | 45.10 | 12.20 | 42.70 | 78.71 | 21.29 | 74.52 | 94.68 | 1.00 | .21 | .09 | |
| +2.80 | 3063 | 42.50 | 16.00 | 41.60 | 72.65 | 27.35 | 71.11 | 97.88 | .42 | .11 | .05 | |
| +3.35 | 4000 | 43.70 | 13.70 | 42.60 | 76.13 | 23.87 | 74.22 | 97.48 | .38 | .09 | .04 | |
| | | | | | | | | | 100.00 | 21.70 | 9.05 | |

PCA MODAL MINERALOGY AUG. 27,1987

REGRIND FLOATATION CONCENTRATE #5137

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WT. WEIGHTED | = SYLVITE | .06 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 14.80 | 70.50 | 14.70 | 17.35 | 82.65 | 17.23 | 99.32 | 4.80 | 3.97 | .24 | |
| +75 | 126 | 13.80 | 72.50 | 13.70 | 15.99 | 84.01 | 15.87 | 99.28 | 28.94 | 24.31 | 1.46 | |
| +212 | 300 | 3.95 | 92.20 | 3.83 | 4.11 | 95.89 | 3.98 | 96.96 | 35.49 | 34.03 | 2.04 | |
| +425 | 505 | 7.86 | 84.80 | 7.37 | 8.48 | 91.52 | 7.95 | 93.77 | 20.08 | 18.38 | 1.10 | |
| +600 | 714 | 6.44 | 87.40 | 6.16 | 6.86 | 93.14 | 6.56 | 95.65 | 8.74 | 8.14 | .49 | |
| +850 | 922 | 7.74 | 84.80 | 7.49 | 8.36 | 91.64 | 8.09 | 96.77 | .52 | .48 | .03 | |
| +1.00MM | 1086 | 9.96 | 80.40 | 9.67 | 11.02 | 88.98 | 10.70 | 97.09 | .40 | .36 | .02 | |
| +1.18 | 1285 | 15.50 | 69.40 | 15.10 | 18.26 | 81.74 | 17.79 | 97.42 | .14 | .11 | .01 | |
| +1.40 | 1543 | 19.00 | 62.20 | 18.80 | 23.40 | 76.60 | 23.15 | 98.95 | .24 | .18 | .01 | |
| +1.70 | 1844 | 21.80 | 56.70 | 21.50 | 27.77 | 72.23 | 27.39 | 98.62 | .19 | .14 | .01 | |
| +2.00 | 2173 | 17.40 | 65.70 | 16.90 | 20.94 | 79.06 | 20.34 | 97.13 | .28 | .22 | .01 | |
| +2.36 | 2571 | 19.10 | 62.50 | 18.40 | 23.41 | 76.59 | 22.55 | 96.34 | .18 | .14 | .01 | |
| +2.80 | 3063 | 17.00 | 66.80 | 16.20 | 20.29 | 79.71 | 19.33 | 95.29 | .01 | .01 | .00 | |
| +3.35 | 4000 | 31.70 | 47.40 | 20.90 | 40.08 | 59.92 | 26.42 | 65.93 | .01 | .01 | .00 | |
| | | | | | | | | | 100.02 | 90.47 | 5.43 | |

PCA MODAL MINERALOGY AUG. 27,1987

REGRIND FLOATATION TAILS #5138

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS. HALITE | HALITE | SYLVITE | DISS. HALITE | % HALITE DISSOL. | WT FACT. | MILL WT. WEIGHTED | = SYLVITE | .36 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 44.20 | 11.70 | 44.10 | 79.07 | 20.93 | 78.89 | 99.77 | .37 | .08 | .03 | |
| +75 | 126 | 48.00 | 4.11 | 47.90 | 92.11 | 7.89 | 91.92 | 99.79 | 4.47 | .35 | .13 | |
| +212 | 300 | 48.40 | 3.14 | 48.40 | 93.91 | 6.09 | 93.91 | 100.00 | 29.54 | 1.80 | .64 | |
| +425 | 505 | 48.30 | 3.14 | 48.20 | 93.90 | 6.10 | 93.70 | 99.79 | 19.67 | 1.20 | .43 | |
| +600 | 714 | 47.60 | 4.89 | 47.50 | 90.68 | 9.32 | 90.49 | 99.79 | 18.16 | 1.69 | .60 | |
| +850 | 922 | 46.40 | 7.17 | 46.40 | 86.62 | 13.38 | 86.62 | 100.00 | 7.60 | 1.02 | .36 | |
| +1.00MM | 1086 | 45.00 | 10.00 | 44.90 | 81.82 | 18.18 | 81.64 | 99.78 | 6.65 | 1.21 | .43 | |
| +1.18 | 1285 | 45.00 | 10.80 | 44.20 | 80.65 | 19.35 | 79.21 | 98.22 | 5.99 | 1.16 | .41 | |
| +1.40 | 1543 | 43.40 | 13.30 | 43.30 | 76.54 | 23.46 | 76.37 | 99.77 | 3.78 | .89 | .32 | |
| +1.70 | 1844 | 44.70 | 10.70 | 44.60 | 80.69 | 19.31 | 80.51 | 99.78 | 1.63 | .31 | .11 | |
| +2.00 | 2173 | 44.00 | 12.10 | 43.90 | 78.43 | 21.57 | 78.25 | 99.77 | 1.25 | .27 | .10 | |
| +2.36 | 2571 | 42.60 | 16.10 | 41.30 | 72.57 | 27.43 | 70.36 | 96.95 | .53 | .15 | .05 | |
| +2.80 | 3063 | 45.60 | 10.70 | 43.70 | 80.99 | 19.01 | 77.62 | 95.83 | .23 | .04 | .02 | |
| +3.35 | 4000 | 47.20 | 11.80 | 40.90 | 80.00 | 20.00 | 69.32 | 86.65 | .13 | .03 | .01 | |
| | | | | | | | | | 100.00 | 10.19 | 3.64 | |

PCA MODAL MINERALOGY AUG. 28, 1987

REGRIND FLOTATION CONCENTRATE #5140

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALIT DISS | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .07 AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 19.70 | 60.90 | 19.40 | 24.44 | 75.56 | 24.07 | 98.48 | 1.33 | 1.00 | .07 | |
| +75 | 126 | 19.90 | 60.60 | 19.50 | 24.72 | 75.28 | 24.22 | 97.99 | 16.00 | 12.04 | .84 | |
| +212 | 300 | 15.50 | 69.40 | 15.10 | 18.26 | 81.74 | 17.79 | 97.42 | 34.58 | 28.27 | 1.98 | |
| +425 | 505 | 14.00 | 72.40 | 13.60 | 16.20 | 83.80 | 15.74 | 97.14 | 11.60 | 9.72 | .68 | |
| +600 | 714 | 15.70 | 69.10 | 15.20 | 18.51 | 81.49 | 17.92 | 96.82 | 18.53 | 15.10 | 1.06 | |
| +850 | 922 | 16.10 | 68.00 | 15.90 | 19.14 | 80.86 | 18.91 | 98.76 | 5.33 | 4.31 | .30 | |
| +1.00MM | 1086 | 18.20 | 63.90 | 17.90 | 22.17 | 77.83 | 21.80 | 98.35 | 2.53 | 1.97 | .14 | |
| +1.18 | 1285 | 22.90 | 55.50 | 21.70 | 29.21 | 70.79 | 27.68 | 94.76 | 1.43 | 1.01 | .07 | |
| +1.40 | 1543 | 21.90 | 56.40 | 21.70 | 27.97 | 72.03 | 27.71 | 99.09 | 1.33 | .96 | .07 | |
| +1.70 | 1844 | 18.30 | 63.70 | 18.00 | 22.32 | 77.68 | 21.95 | 98.36 | 1.16 | .90 | .06 | |
| +2.00 | 2173 | 22.10 | 56.60 | 21.30 | 28.08 | 71.92 | 27.06 | 96.38 | 1.24 | .89 | .06 | |
| +2.36 | 2571 | 21.50 | 58.20 | 20.30 | 26.98 | 73.02 | 25.47 | 94.42 | 1.21 | .88 | .06 | |
| +2.80 | 3063 | 21.80 | 57.30 | 20.90 | 27.56 | 72.44 | 26.42 | 95.87 | 1.05 | .76 | .05 | |
| +3.35 | 4000 | 20.10 | 61.20 | 18.70 | 24.72 | 75.28 | 23.00 | 93.03 | 2.67 | 2.01 | .14 | |
| | | | | | | | | | 99.99 | 79.83 | 5.59 | |

PCA MODAL MINERALOGY AUG. 28, 1987

ROUGHER FLOTATION TAILS #5141

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALIT DISS | WT FACT. | MILL WEIGHTED | WT = SYLVITE % | .71 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +38 NM | 53 | 42.60 | 15.10 | 42.20 | 73.83 | 26.17 | 73.14 | 99.06 | .20 | .05 | .04 | |
| +75 | 126 | 47.90 | 4.22 | 47.90 | 91.90 | 8.10 | 91.90 | 100.00 | 3.83 | .31 | .22 | |
| +212 | 300 | 48.70 | 2.80 | 48.50 | 94.56 | 5.44 | 94.17 | 99.59 | 13.09 | .71 | .51 | |
| +425 | 505 | 48.70 | 2.74 | 48.60 | 94.67 | 5.33 | 94.48 | 99.79 | 12.40 | .66 | .47 | |
| +600 | 714 | 47.40 | 5.26 | 47.30 | 90.01 | 9.99 | 89.82 | 99.79 | 17.51 | 1.75 | 1.25 | |
| +850 | 922 | 45.60 | 9.41 | 45.00 | 82.89 | 17.11 | 81.80 | 98.68 | 10.09 | 1.73 | 1.23 | |
| +1.00MM | 1086 | 43.60 | 12.80 | 43.60 | 77.30 | 22.70 | 77.30 | 100.00 | 9.72 | 2.21 | 1.57 | |
| +1.18 | 1285 | 44.40 | 11.50 | 44.10 | 79.43 | 20.57 | 78.89 | 99.32 | 8.77 | 1.80 | 1.29 | |
| +1.40 | 1543 | 43.40 | 13.20 | 43.40 | 76.68 | 23.32 | 76.68 | 100.00 | 8.43 | 1.97 | 1.40 | |
| +1.70 | 1844 | 43.80 | 12.80 | 43.40 | 77.39 | 22.61 | 76.68 | 99.09 | 4.85 | 1.10 | .78 | |
| +2.00 | 2173 | 44.50 | 11.00 | 44.40 | 80.18 | 19.82 | 80.00 | 99.78 | 4.53 | .90 | .64 | |
| +2.36 | 2571 | 42.40 | 15.30 | 42.30 | 73.48 | 26.52 | 73.31 | 99.76 | 2.89 | .77 | .55 | |
| +2.80 | 3063 | 44.00 | 12.90 | 43.20 | 77.33 | 22.67 | 75.92 | 98.18 | 2.06 | .47 | .33 | |
| +3.35 | 4000 | 44.10 | 14.00 | 41.90 | 75.90 | 24.10 | 72.12 | 95.01 | 1.63 | .39 | .28 | |
| | | | | | | | | | 100.00 | 14.81 | 10.56 | |

PCA MODAL MINERALOGY AUG. 28, 1987

REGRIND FLOTATION TAILS #5142

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS. HALITE | HALITE | SYLVITE | DISS. HALITE | % HALIT DISS | WT FACT. | MILL WEIGHTED | WT = SYLVITE AREA .39 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 43.80 | 12.70 | 43.60 | 77.52 | 22.48 | 77.17 | 99.54 | .44 | .10 | .04 |
| +75 | 126 | 48.80 | 2.97 | 48.30 | 94.26 | 5.74 | 93.30 | 98.98 | 5.77 | .33 | .13 |
| +212 | 300 | 48.80 | 2.33 | 48.80 | 95.44 | 4.56 | 95.44 | 100.00 | 15.22 | .69 | .27 |
| +425 | 505 | 49.00 | 1.98 | 49.00 | 96.12 | 3.88 | 96.12 | 100.00 | 11.43 | .44 | .17 |
| +600 | 714 | 47.50 | 5.04 | 47.50 | 90.41 | 9.59 | 90.41 | 100.00 | 15.93 | 1.53 | .60 |
| +850 | 922 | 46.30 | 7.41 | 46.30 | 86.20 | 13.80 | 86.20 | 100.00 | 9.71 | 1.34 | .53 |
| +1.00MM | 1086 | 45.80 | 8.50 | 45.70 | 84.35 | 15.65 | 84.16 | 99.78 | 8.39 | 1.31 | .52 |
| +1.18 | 1285 | 43.50 | 13.00 | 43.50 | 76.99 | 23.01 | 76.99 | 100.00 | 7.60 | 1.75 | .69 |
| +1.40 | 1543 | 43.90 | 12.40 | 43.70 | 77.98 | 22.02 | 77.62 | 99.54 | 9.03 | 1.99 | .78 |
| +1.70 | 1844 | 43.60 | 12.90 | 43.50 | 77.17 | 22.83 | 76.99 | 99.77 | 4.82 | 1.10 | .43 |
| +2.00 | 2173 | 44.00 | 12.20 | 43.90 | 78.29 | 21.71 | 78.11 | 99.77 | 4.92 | 1.07 | .42 |
| +2.36 | 2571 | 44.00 | 12.20 | 43.80 | 78.29 | 21.71 | 77.94 | 99.55 | 3.30 | .72 | .28 |
| +2.80 | 3063 | 41.70 | 17.00 | 41.30 | 71.04 | 28.96 | 70.36 | 99.04 | 2.10 | .61 | .24 |
| +3.35 | 4000 | 45.00 | 15.80 | 39.20 | 74.01 | 25.99 | 64.47 | 87.11 | 1.33 | .35 | .14 |
| | | | | | | | | | 99.99 | 13.32 | 5.24 |

PCA MODAL MINERALOGY AUG. 28, 1987

BALL MILL DISCHARGE #5143

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALIT DISS | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .46 AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +38 NM | 53 | 42.90 | 14.50 | 42.60 | 74.74 | 25.26 | 74.22 | 99.30 | .10 | .03 | .01 | |
| +75 | 126 | 44.20 | 11.70 | 44.10 | 79.07 | 20.93 | 78.89 | 99.77 | 1.14 | .24 | .11 | |
| +212 | 300 | 44.50 | 11.00 | 44.50 | 80.18 | 19.82 | 80.18 | 100.00 | 18.60 | 3.69 | 1.71 | |
| +425 | 505 | 45.00 | 10.10 | 44.90 | 81.67 | 18.33 | 81.49 | 99.78 | 12.74 | 2.34 | 1.08 | |
| +600 | 714 | 46.00 | 8.07 | 46.00 | 85.07 | 14.93 | 85.07 | 100.00 | 20.06 | 2.99 | 1.39 | |
| +850 | 922 | 46.10 | 8.17 | 45.70 | 84.95 | 15.05 | 84.21 | 99.13 | 10.65 | 1.60 | .74 | |
| +1.00MM | 1086 | 43.10 | 14.00 | 42.80 | 75.48 | 24.52 | 74.96 | 99.30 | 9.10 | 2.23 | 1.03 | |
| +1.18 | 1285 | 43.70 | 12.60 | 43.70 | 77.62 | 22.38 | 77.62 | 100.00 | 7.66 | 1.71 | .79 | |
| +1.40 | 1543 | 42.70 | 14.80 | 42.50 | 74.26 | 25.74 | 73.91 | 99.53 | 8.21 | 2.11 | .98 | |
| +1.70 | 1844 | 42.90 | 15.50 | 41.60 | 73.46 | 26.54 | 71.23 | 96.97 | 3.85 | 1.02 | .47 | |
| +2.00 | 2173 | 44.40 | 11.40 | 44.30 | 79.57 | 20.43 | 79.39 | 99.77 | 3.47 | .71 | .33 | |
| +2.36 | 2571 | 43.00 | 15.40 | 41.60 | 73.63 | 26.37 | 71.23 | 96.74 | 2.19 | .58 | .27 | |
| +2.80 | 3063 | 46.50 | 6.98 | 46.50 | 86.95 | 13.05 | 86.95 | 100.00 | 1.37 | .18 | .08 | |
| +3.35 | 4000 | 38.30 | 24.20 | 37.40 | 61.28 | 38.72 | 59.84 | 97.65 | .86 | .33 | .15 | |
| | | | | | | | | | 100.00 | 19.76 | 9.15 | |

PCA MODAL MINERALOGY AUG. 28, 1987

ROUGHER FLOTATION FEED RPC #5144

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALIT DISS. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | 1.00 AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 31.60 | 37.00 | 31.40 | 46.06 | 53.94 | 45.77 | 99.37 | .17 | .09 | .09 | |
| +75 | 126 | 34.00 | 32.10 | 33.90 | 51.44 | 48.56 | 51.29 | 99.71 | 1.83 | .89 | .89 | |
| +212 | 300 | 34.00 | 32.00 | 33.90 | 51.52 | 48.48 | 51.36 | 99.71 | 7.62 | 3.69 | 3.69 | |
| +425 | 505 | 36.90 | 26.50 | 36.60 | 58.20 | 41.80 | 57.73 | 99.19 | 9.34 | 3.90 | 3.90 | |
| +600 | 714 | 39.00 | 22.00 | 38.90 | 63.93 | 36.07 | 63.77 | 99.74 | 14.80 | 5.34 | 5.34 | |
| +850 | 922 | 39.70 | 21.10 | 39.10 | 65.30 | 34.70 | 64.31 | 98.49 | 9.35 | 3.24 | 3.24 | |
| +1.00MM | 1086 | 40.90 | 18.60 | 40.50 | 68.74 | 31.26 | 68.07 | 99.02 | 8.70 | 2.72 | 2.72 | |
| +1.18 | 1285 | 41.90 | 16.60 | 41.50 | 71.62 | 28.38 | 70.94 | 99.05 | 8.80 | 2.50 | 2.50 | |
| +1.40 | 1543 | 39.40 | 21.30 | 39.20 | 64.91 | 35.09 | 64.58 | 99.49 | 10.09 | 3.54 | 3.54 | |
| +1.70 | 1844 | 40.30 | 20.40 | 39.30 | 66.39 | 33.61 | 64.74 | 97.52 | 6.63 | 2.23 | 2.23 | |
| +2.00 | 2173 | 42.50 | 16.80 | 40.80 | 71.67 | 28.33 | 68.80 | 96.00 | 7.83 | 2.22 | 2.22 | |
| +2.36 | 2571 | 42.50 | 17.40 | 40.10 | 70.95 | 29.05 | 66.94 | 94.35 | 6.45 | 1.87 | 1.87 | |
| +2.80 | 3063 | 43.60 | 15.30 | 41.10 | 74.02 | 25.98 | 69.78 | 94.27 | 4.77 | 1.24 | 1.24 | |
| +3.35 | 4000 | 39.50 | 26.10 | 34.50 | 60.21 | 39.79 | 52.59 | 87.34 | 3.62 | 1.44 | 1.44 | |
| | | | | | | | | | 100.00 | 34.92 | 34.92 | |

PCA MODAL MINERALOGY AUG. 28, 1987

BALL MILL FEED #5145

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALIT DISS | WT FACT. | MILL WEIGHTED | WT = SYLVITE AREA | .46 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 37.40 | 25.40 | 37.20 | 59.55 | 40.45 | 59.24 | 99.47 | .08 | .03 | .01 | |
| +75 | 126 | 46.70 | 6.82 | 46.50 | 87.26 | 12.74 | 86.88 | 99.57 | .59 | .08 | .03 | |
| +212 | 300 | 48.60 | 2.79 | 48.60 | 94.57 | 5.43 | 94.57 | 100.00 | 3.33 | .18 | .08 | |
| +425 | 505 | 48.70 | 3.13 | 48.20 | 93.96 | 6.04 | 93.00 | 98.97 | 5.34 | .32 | .15 | |
| +600 | 714 | 46.70 | 6.77 | 46.60 | 87.34 | 12.66 | 87.15 | 99.79 | 9.92 | 1.26 | .58 | |
| +850 | 922 | 45.70 | 8.69 | 45.60 | 84.02 | 15.98 | 83.84 | 99.78 | 10.05 | 1.61 | .74 | |
| +1.00MM | 1086 | 46.10 | 7.93 | 45.90 | 85.32 | 14.68 | 84.95 | 99.57 | 12.23 | 1.80 | .83 | |
| +1.18 | 1285 | 45.10 | 9.82 | 45.10 | 82.12 | 17.88 | 82.12 | 100.00 | 12.27 | 2.19 | 1.02 | |
| +1.40 | 1543 | 44.80 | 10.60 | 44.60 | 80.87 | 19.13 | 80.51 | 99.55 | 16.90 | 3.23 | 1.50 | |
| +1.70 | 1844 | 41.00 | 18.10 | 40.90 | 69.37 | 30.63 | 69.20 | 99.76 | 8.30 | 2.54 | 1.18 | |
| +2.00 | 2173 | 43.70 | 13.00 | 43.40 | 77.07 | 22.93 | 76.54 | 99.31 | 8.01 | 1.84 | .85 | |
| +2.36 | 2571 | 43.10 | 14.10 | 42.70 | 75.35 | 24.65 | 74.65 | 99.07 | 5.71 | 1.41 | .65 | |
| +2.80 | 3063 | 44.70 | 12.80 | 42.50 | 77.74 | 22.26 | 73.91 | 95.08 | 3.72 | .83 | .38 | |
| +3.35 | 4000 | 46.60 | 7.82 | 45.60 | 85.63 | 14.37 | 83.79 | 97.85 | 3.56 | .51 | .24 | |
| | | | | | | | | | 100.01 | 17.82 | 8.25 | |

PCA MODAL MINERALOGY AUG. 28, 1987

ROUGHER FLOTAION CONCENTRATE #5146

| SYLVITE AREA % FRACTION | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALIT DISS | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .29 AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 13.80 | 72.60 | 13.70 | 15.97 | 84.03 | 15.86 | 99.28 | 2.24 | 1.88 | .54 | |
| +75 | 126 | 18.30 | 63.50 | 18.20 | 22.37 | 77.63 | 22.25 | 99.45 | 10.87 | 8.44 | 2.42 | |
| +212 | 300 | 15.00 | 70.20 | 14.80 | 17.61 | 82.39 | 17.37 | 98.67 | 21.94 | 18.08 | 5.19 | |
| +425 | 505 | 10.50 | 79.30 | 10.20 | 11.69 | 88.31 | 11.36 | 97.14 | 20.97 | 18.52 | 5.31 | |
| +600 | 714 | 7.12 | 86.10 | 6.78 | 7.64 | 92.36 | 7.27 | 95.22 | 22.05 | 20.37 | 5.85 | |
| +850 | 922 | 4.73 | 90.80 | 4.49 | 4.95 | 95.05 | 4.70 | 94.93 | 7.79 | 7.40 | 2.13 | |
| +1.00MM | 1086 | 4.68 | 90.80 | 4.47 | 4.90 | 95.10 | 4.68 | 95.51 | 5.33 | 5.07 | 1.45 | |
| +1.18 | 1285 | 5.13 | 90.00 | 4.87 | 5.39 | 94.61 | 5.12 | 94.93 | 3.08 | 2.91 | .84 | |
| +1.40 | 1543 | 5.80 | 89.00 | 5.17 | 6.12 | 93.88 | 5.45 | 89.14 | 1.86 | 1.75 | .50 | |
| +1.70 | 1844 | 14.20 | 72.30 | 13.40 | 16.42 | 83.58 | 15.49 | 94.37 | .78 | .65 | .19 | |
| +2.00 | 2173 | 13.30 | 75.10 | 11.60 | 15.05 | 84.95 | 13.12 | 87.22 | .71 | .60 | .17 | |
| +2.36 | 2571 | 20.00 | 61.30 | 18.70 | 24.60 | 75.40 | 23.00 | 93.50 | .60 | .45 | .13 | |
| +2.80 | 3063 | 23.70 | 55.90 | 20.40 | 29.77 | 70.23 | 25.63 | 86.08 | .68 | .48 | .14 | |
| +3.35 | 4000 | 37.20 | 52.60 | 10.20 | 41.43 | 58.57 | 11.36 | 27.42 | 1.10 | .64 | .18 | |
| | | | | | | | | | 100.00 | 87.24 | 25.04 | |

Liberation data for PCA mill samples collected August 27, 1987.

ROUGHER FLOTATION FEED #5132

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86% NORMAL. | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. | CUM WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.2e5 | 3.2e6 | 3.5e6 | 3.8e6 | 1.60 | 1.47 | 25.80 | 5.71 | 100.00 | 53 | 99.99 | 35.71 |
| +75 | 9.9e5 | 1.4e7 | 1.5e7 | 1.9e7 | 5.63 | 4.55 | 24.33 | 17.63 | 94.29 | 126 | 97.25 | 34.73 |
| +212 | 4.9e6 | 2.8e7 | 3.3e7 | 4.2e7 | 7.46 | 5.78 | 19.78 | 22.39 | 76.66 | 300 | 83.65 | 29.87 |
| +425 | 5.1e6 | 2.6e7 | 3.1e7 | 3.8e7 | 5.89 | 4.79 | 14.00 | 18.58 | 54.27 | 505 | 63.26 | 22.59 |
| +600 | 4.5e6 | 3.2e7 | 3.6e7 | 4.9e7 | 5.20 | 3.83 | 9.21 | 14.84 | 35.68 | 714 | 48.26 | 17.23 |
| +850 | 5.6e6 | 2.8e7 | 3.4e7 | 4.5e7 | 2.22 | 1.69 | 5.38 | 6.57 | 20.84 | 922 | 34.83 | 12.44 |
| +1000 | 4.2e6 | 1.8e7 | 2.2e7 | 3.0e7 | 1.36 | 1.00 | 3.68 | 3.86 | 14.28 | 1086 | 28.99 | 10.35 |
| +1180 | 4.5e6 | 1.5e7 | 1.9e7 | 2.6e7 | 1.54 | 1.14 | 2.69 | 4.41 | 10.42 | 1285 | 23.65 | 8.45 |
| +1400 | 5.3e6 | 1.6e7 | 2.1e7 | 5.1e7 | 1.53 | .63 | 1.55 | 2.45 | 6.01 | 1543 | 18.09 | 6.46 |
| +1700 | 4.5e6 | 1.6e7 | 2.0e7 | 4.8e7 | .85 | .35 | .92 | 1.38 | 3.56 | 1844 | 12.72 | 4.54 |
| +2000 | 5.3e6 | 1.2e7 | 1.7e7 | 4.0e7 | .90 | .38 | .56 | 1.48 | 2.18 | 2173 | 9.73 | 3.47 |
| +2360 | 1.3e6 | 8.3e6 | 9.7e6 | 3.8e7 | .52 | .13 | .18 | .51 | .71 | 2571 | 5.87 | 2.10 |
| +2800 | 2e5 | 4.4e6 | 4.6e6 | 4.3e7 | .48 | .05 | .05 | .20 | .20 | 3063 | 3.28 | 1.17 |
| +3350 | 0 | 0 | 0 | 4.1e7 | .53 | .00 | .00 | .00 | .00 | 4000 | 1.52 | .54 |
| | | | | | 35.71 | 25.80 | | 100.00 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION TAILS #5133

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.2e5 | 1.4e6 | 1.7e6 | 2.0e6 | .44 | .36 | 4.36 | 8.32 | 100.00 | 53 |
| +75 | 3.0e5 | 2.8e6 | 3.1e6 | 4.9e6 | .76 | .49 | 4.00 | 11.15 | 91.68 | 126 |
| +212 | 1.3e6 | 6.0e6 | 7.3e6 | 1.1e7 | 1.12 | .72 | 3.51 | 16.60 | 80.53 | 300 |
| +425 | 1.7e6 | 4.1e6 | 5.8e6 | 9.4e6 | .84 | .52 | 2.79 | 11.91 | 63.93 | 505 |
| +600 | 1.6e6 | 2.8e6 | 4.4e6 | 9.0e6 | .59 | .29 | 2.27 | 6.59 | 52.02 | 714 |
| +850 | 3.1e6 | 3.1e6 | 6.2e6 | 1.4e7 | .43 | .20 | 1.98 | 4.51 | 45.43 | 922 |
| +1000 | 2.3e6 | 3.5e6 | 5.8e6 | 1.2e7 | .40 | .19 | 1.79 | 4.39 | 40.93 | 1086 |
| +1180 | 6.2e6 | 6.4e6 | 1.3e7 | 2.1e7 | .76 | .45 | 1.59 | 10.30 | 36.54 | 1285 |
| +1400 | 8.4e6 | 1.6e7 | 2.5e7 | 3.8e7 | 1.02 | .67 | 1.15 | 15.32 | 26.24 | 1543 |
| +1700 | 5.7e6 | 2.8e6 | 8.5e6 | 2.6e7 | .46 | .15 | .48 | 3.45 | 10.92 | 1844 |
| +2000 | 7.0e5 | 3.3e6 | 4.0e6 | 1.8e7 | .46 | .10 | .33 | 2.35 | 7.47 | 2173 |
| +2360 | 7.1e6 | 0 | 7.1e6 | 4.1e7 | .65 | .11 | .22 | 2.57 | 5.12 | 2571 |
| +2800 | 4.7e6 | 5.6e6 | 1.0e7 | 4.0e7 | .28 | .07 | .11 | 1.64 | 2.56 | 3063 |
| +3350 | 6.0e5 | 2.9e6 | 3.5e6 | 2.1e7 | .24 | .04 | .04 | .91 | .91 | 4000 |
| | | | | | 8.45 | 4.36 | | 100.00 | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION CONCENTRATE #5134

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 5.8e5 | 3.8e6 | 4.3e6 | 4.6e6 | 1.33 | 1.26 | 29.47 | 4.27 | 100.00 | 53 |
| +75 | 2.8e6 | 2.3e7 | 2.5e7 | 2.7e7 | 3.39 | 3.22 | 28.21 | 10.93 | 95.73 | 126 |
| +212 | 1.1e7 | 8.1e7 | 9.3e7 | 9.8e7 | 7.02 | 6.65 | 24.99 | 22.56 | 84.80 | 300 |
| +425 | 7.6e6 | 7.8e7 | 8.6e7 | 9.1e7 | 7.42 | 6.98 | 18.34 | 23.67 | 62.25 | 505 |
| +600 | 1.2e7 | 9.9e7 | 1.1e8 | 1.2e8 | 6.02 | 5.63 | 11.37 | 19.11 | 38.57 | 714 |
| +850 | 1.8e7 | 9.3e7 | 1.1e8 | 1.2e8 | 2.25 | 2.11 | 5.74 | 7.15 | 19.47 | 922 |
| +1000 | 2.2e7 | 7.6e7 | 9.7e7 | 1.1e8 | 1.78 | 1.65 | 3.63 | 5.60 | 12.32 | 1086 |
| +1180 | 5.1e6 | 8.5e7 | 9.0e7 | 1e8 | 1.31 | 1.18 | 1.98 | 4.01 | 6.71 | 1285 |
| +1400 | 1.3e7 | 1.0e8 | 1.2e8 | 1.2e8 | .57 | .56 | .80 | 1.90 | 2.70 | 1543 |
| +1700 | 1.3e7 | 1.0e8 | 1.2e8 | 1.3e8 | .18 | .16 | .24 | .54 | .80 | 1844 |
| +2000 | 4.2e7 | 3.8e7 | 8.0e7 | 1.0e8 | .09 | .07 | .08 | .24 | .27 | 2173 |
| +2360 | 8.8e5 | 2.4e7 | 2.5e7 | 6.8e7 | .02 | .01 | .01 | .02 | .02 | 2571 |
| +2800 | 5.6e5 | 1.0e7 | 1.1e7 | 3.6e7 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 1.5e5 | 0 | 1.5e5 | 2.1e7 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 31.38 | 29.47 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

BALL MILL FEED #5135

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 4.0e5 | 2.2e6 | 2.6e6 | 2.9e6 | .00 | .00 | 3.85 | .00 | 100.00 | 53 | 100.00 |
| +75 | 7.1e5 | 5.6e6 | 6.3e6 | 7.7e6 | .06 | .05 | 3.85 | 1.28 | 100.00 | 126 | 99.53 |
| +212 | 8.5e5 | 3.9e6 | 4.8e6 | 7.5e6 | .08 | .05 | 3.80 | 1.33 | 98.72 | 300 | 91.77 |
| +425 | 1.7e4 | 1.6e6 | 1.7e6 | 4.6e6 | .08 | .03 | 3.75 | .75 | 97.39 | 505 | 67.15 |
| +600 | 1.3e6 | 6.8e6 | 8.1e6 | 1.4e7 | .47 | .26 | 3.72 | 6.84 | 96.64 | 714 | 45.47 |
| +850 | 8.9e5 | 1.2e7 | 1.3e7 | 2.1e7 | .63 | .39 | 3.46 | 10.18 | 89.80 | 922 | 28.07 |
| +1000 | 2.3e6 | 1.4e7 | 1.6e7 | 2.4e7 | 1.00 | .67 | 3.07 | 17.49 | 79.62 | 1086 | 20.93 |
| +1180 | 1.9e6 | 7.9e6 | 9.8e6 | 1.6e7 | .90 | .54 | 2.39 | 13.99 | 62.13 | 1285 | 14.96 |
| +1400 | 6.0e6 | 1.3e7 | 1.8e7 | 4.4e7 | 1.52 | .64 | 1.85 | 16.59 | 48.14 | 1543 | 9.64 |
| +1700 | 4.5e6 | 1.1e7 | 1.6e7 | 3.6e7 | .79 | .34 | 1.21 | 8.89 | 31.55 | 1844 | 5.59 |
| +2000 | 1.0e7 | 9.8e6 | 2.0e7 | 5.1e7 | 1.32 | .51 | .87 | 13.32 | 22.66 | 2173 | 3.68 |
| +2360 | 7.5e6 | 1.4e7 | 2.2e7 | 5.6e7 | .87 | .34 | .36 | 8.83 | 9.33 | 2571 | 1.80 |
| +2800 | 9.4e5 | 6.4e5 | 1.6e6 | 3.9e7 | .47 | .02 | .02 | .50 | .50 | 3063 | .80 |
| +3350 | 0 | 0 | 0 | 2.2e7 | .21 | .00 | .00 | .00 | .00 | 4000 | .38 |
| | | | | | 8.40 | 3.85 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

BALL MILL DISCHARGE #5136

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. | CUM WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.5e5 | 6.7e5 | 9.1e5 | 1.1e6 | .04 | .03 | 4.85 | .66 | 100.00 | 53 | 100.00 | 9.05 |
| +75 | 1.8e6 | 5.2e6 | 7.0e6 | 9.2e6 | .74 | .56 | 4.82 | 11.54 | 99.34 | 126 | 99.53 | 9.01 |
| +212 | 7.2e6 | 4.7e6 | 1.2e7 | 2.3e7 | 2.49 | 1.31 | 4.26 | 27.08 | 87.80 | 300 | 91.77 | 8.31 |
| +425 | 6.5e6 | 7.5e6 | 1.4e7 | 2.2e7 | 2.22 | 1.41 | 2.94 | 28.98 | 60.72 | 505 | 67.15 | 6.08 |
| +600 | 8.1e6 | 5.8e6 | 1.4e7 | 2.6e7 | 1.58 | .85 | 1.54 | 17.48 | 31.74 | 714 | 45.47 | 4.12 |
| +850 | 3.8e6 | 3.2e6 | 7.0e6 | 1.9e7 | .42 | .16 | .69 | 3.27 | 14.26 | 922 | 28.07 | 2.54 |
| +1000 | 3.7e6 | 4.0e6 | 7.7e6 | 2.1e7 | .46 | .17 | .53 | 3.56 | 10.99 | 1086 | 20.93 | 1.89 |
| +1180 | 1.3e6 | 1.6e6 | 2.9e6 | 1.1e7 | .22 | .06 | .36 | 1.20 | 7.42 | 1285 | 14.96 | 1.35 |
| +1400 | 4.8e6 | 6.2e6 | 1.1e7 | 2.8e7 | .30 | .12 | .30 | 2.42 | 6.22 | 1543 | 9.64 | .87 |
| +1700 | 1.7e5 | 1.6e7 | 1.6e7 | 4.1e7 | .19 | .07 | .18 | 1.54 | 3.81 | 1844 | 5.59 | .51 |
| +2000 | 1.2e7 | 4.7e6 | 1.7e7 | 4.3e7 | .21 | .08 | .11 | 1.68 | 2.27 | 2173 | 3.68 | .33 |
| +2360 | 2.1e6 | 0 | 2.1e6 | 3.0e7 | .09 | .01 | .03 | .13 | .59 | 2571 | 1.80 | .16 |
| +2800 | 1.5e7 | 6.5e5 | 1.6e7 | 4.7e7 | .05 | .02 | .02 | .34 | .46 | 3063 | .80 | .07 |
| +3350 | 3.8e6 | 4.1e5 | 4.2e6 | 3.0e7 | .04 | .01 | .01 | .11 | .11 | 4000 | .38 | .03 |
| | | | | | 9.05 | 4.85 | | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGRIND FLOATATION CONCETRATE #5137

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE F FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 3.5e5 | 6.0e6 | 6.4e6 | 6.6e6 | .24 | .23 | 5.01 | 4.60 | 100.00 | 53 |
| +75 | 2.6e6 | 2.8e7 | 3.0e7 | 3.3e7 | 1.46 | 1.36 | 4.78 | 27.06 | 95.40 | 126 |
| +212 | 1.1e7 | 8.5e7 | 9.6e7 | 1.0e8 | 2.04 | 1.91 | 3.42 | 38.12 | 68.34 | 300 |
| +425 | 1.3e7 | 7.3e7 | 8.6e7 | 9.4e7 | 1.10 | 1.01 | 1.51 | 20.19 | 30.22 | 505 |
| +600 | 2.3e7 | 8.3e7 | 1.1e8 | 1.2e8 | .49 | .45 | .50 | 8.89 | 10.03 | 714 |
| +850 | 2.0e7 | 8.0e7 | 9.9e7 | 1.1e8 | .03 | .03 | .06 | .54 | 1.14 | 922 |
| +1000 | 2.2e7 | 5.5e7 | 7.6e7 | 9.0e7 | .02 | .02 | .03 | .34 | .59 | 1086 |
| +1180 | 2.0e7 | 1.7e7 | 3.8e7 | 6.9e7 | .01 | .01 | .01 | .11 | .26 | 1285 |
| +1400 | 1.4e7 | 5.6e6 | 1.9e7 | 6.7e7 | .01 | .00 | .01 | .06 | .15 | 1543 |
| +1700 | 3.4e6 | 1.7e6 | 5.2e6 | 6.0e7 | .01 | .00 | .00 | .02 | .09 | 1844 |
| +2000 | 1.1e7 | 3.0e6 | 1.4e7 | 6.7e7 | .01 | .00 | .00 | .04 | .07 | 2173 |
| +2360 | 6.9e6 | 2.1e6 | 9.0e6 | 5.9e7 | .01 | .00 | .00 | .03 | .03 | 2571 |
| +2800 | 6.2e6 | 3.1e6 | 9.4e6 | 6.1e7 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 5.4e5 | 0 | 5.4e5 | 6.4e7 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 5.43 | 5.01 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGRIND FLOATATION TAILS #5138

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE F FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 1.7e5 | 8.5e5 | 1.0e6 | 1.2e6 | .03 | .03 | 1.93 | 1.34 | 100.00 | 53 |
| +75 | 4.1e5 | 1.4e6 | 1.8e6 | 3.3e6 | .13 | .07 | 1.90 | 3.75 | 98.66 | 126 |
| +212 | 7.5e5 | 1.9e6 | 2.6e6 | 7.4e6 | .64 | .22 | 1.83 | 11.62 | 94.91 | 300 |
| +425 | 9.1e5 | 2.3e6 | 3.3e6 | 7.3e6 | .43 | .19 | 1.61 | 9.91 | 83.29 | 505 |
| +600 | 3.0e6 | 2.7e6 | 5.7e6 | 1.0e7 | .60 | .33 | 1.42 | 17.29 | 73.38 | 714 |
| +850 | 7.3e6 | 2.6e6 | 9.8e6 | 1.5e7 | .36 | .24 | 1.08 | 12.50 | 56.08 | 922 |
| +1000 | 4.9e6 | 9.4e6 | 1.4e7 | 2.1e7 | .43 | .29 | .84 | 14.89 | 43.59 | 1086 |
| +1180 | 5.1e6 | 1.1e7 | 1.7e7 | 2.4e7 | .41 | .29 | .55 | 14.87 | 28.70 | 1285 |
| +1400 | 5.6e6 | 1.2e7 | 1.8e7 | 3.7e7 | .32 | .15 | .27 | 7.96 | 13.82 | 1543 |
| +1700 | 7.3e6 | 2.6e6 | 9.8e6 | 3.4e7 | .11 | .03 | .11 | 1.67 | 5.87 | 1844 |
| +2000 | 6.5e6 | 1.2e7 | 1.8e7 | 3.6e7 | .10 | .05 | .08 | 2.62 | 4.20 | 2173 |
| +2360 | 2.8e6 | 1.5e7 | 1.8e7 | 3.9e7 | .05 | .02 | .03 | 1.18 | 1.58 | 2571 |
| +2800 | 1.1e4 | 1.2e7 | 1.2e7 | 3.3e7 | .02 | .01 | .01 | .36 | .41 | 3063 |
| +3350 | 5.0e4 | 2e6 | 2.1e6 | 2.4e7 | .01 | .00 | .00 | .05 | .05 | 4000 |
| | | | | | 3.64 | 1.93 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

Liberation study for PCA mill samples collected August 28, 1987

REGRIND FLOTATION CONCETRATE #5140

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 6.2e5 | 3.7e6 | 4.3e6 | 4.7e6 | .07 | .06 | 4.06 | 1.58 | 100.00 | 53 |
| +75 | 6.3e6 | 2.0e7 | 2.6e7 | 3e7 | .84 | .73 | 3.99 | 18.05 | 98.42 | 126 |
| +212 | 1.8e7 | 5.6e7 | 7.5e7 | 8.9e7 | 1.98 | 1.66 | 3.26 | 40.89 | 80.37 | 300 |
| +425 | 2.1e7 | 4.6e7 | 6.7e7 | 8.6e7 | .68 | .53 | 1.60 | 12.98 | 39.48 | 505 |
| +600 | 2.7e7 | 3.3e7 | 6.0e7 | 8.6e7 | 1.06 | .74 | 1.08 | 18.13 | 26.50 | 714 |
| +850 | 2.5e7 | 2.0e7 | 4.5e7 | 6.9e7 | .3 | .19 | .34 | 4.79 | 8.37 | 922 |
| +1000 | 2.0e7 | 1.4e7 | 3.4e7 | 5.9e7 | .14 | .08 | .15 | 1.99 | 3.58 | 1086 |
| +1180 | 8.3e6 | 4.2e6 | 1.2e7 | 4.9e7 | .07 | .02 | .06 | .44 | 1.58 | 1285 |
| +1400 | 1.0e7 | 2.1e6 | 1.2e7 | 5.1e7 | .07 | .02 | .05 | .41 | 1.15 | 1543 |
| +1700 | 8.6e6 | 4.1e6 | 1.3e7 | 4.6e7 | .06 | .02 | .03 | .41 | .74 | 1844 |
| +2000 | 2.2e6 | 3.5e6 | 5.7e6 | 7.2e7 | .06 | .00 | .01 | .12 | .32 | 2173 |
| +2360 | 2e6 | 1.4e6 | 3.4e6 | 5.4e7 | .06 | .00 | .01 | .09 | .21 | 2571 |
| +2800 | 1.6e6 | 1.8e6 | 3.4e6 | 6.9e7 | .05 | .00 | .00 | .06 | .11 | 3063 |
| +3350 | 5.3e5 | 4.6e5 | 1.0e6 | 6.7e7 | .14 | .00 | .00 | .05 | .05 | 4000 |
| | | | | | 5.58 | 4.06 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION TAILS #5141

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 3.8e5 | 1.2e6 | 1.6e6 | 2.0e6 | .04 | .03 | 6.24 | .51 | 100.00 | 53 |
| +75 | 6.2e5 | 1.2e6 | 1.8e6 | 3.2e6 | .22 | .13 | 6.21 | 2.05 | 99.49 | 126 |
| +212 | 1.4e6 | 1.8e6 | 3.2e6 | 6.3e6 | .51 | .26 | 6.08 | 4.10 | 97.44 | 300 |
| +425 | 8.2e5 | 1.6e6 | 2.4e6 | 5.3e6 | .47 | .22 | 5.83 | 3.45 | 93.35 | 505 |
| +600 | 3.9e6 | 4.4e6 | 8.3e6 | 1.3e7 | 1.25 | .79 | 5.61 | 12.62 | 89.90 | 714 |
| +850 | 2.9e6 | 1.1e7 | 1.3e7 | 1.9e7 | 1.23 | .86 | 4.82 | 13.84 | 77.28 | 922 |
| +1000 | 4.5e6 | 1.1e7 | 1.5e7 | 2.3e7 | 1.57 | 1.01 | 3.96 | 16.16 | 63.43 | 1086 |
| +1180 | 3.0e6 | 1.1e7 | 1.4e7 | 2.2e7 | 1.29 | .82 | 2.95 | 13.07 | 47.27 | 1285 |
| +1400 | 9.3e6 | 1.2e7 | 2.2e7 | 3.9e7 | 1.4 | .77 | 2.14 | 12.38 | 34.21 | 1543 |
| +1700 | 6.8e6 | 1.2e7 | 1.8e7 | 2.9e7 | .78 | .49 | 1.36 | 7.90 | 21.82 | 1844 |
| +2000 | 6.8e6 | 5.2e6 | 1.2e7 | 2.3e7 | .64 | .34 | .87 | 5.41 | 13.92 | 2173 |
| +2360 | 1.4e7 | 1.0e7 | 2.4e7 | 3.8e7 | .55 | .35 | .53 | 5.58 | 8.51 | 2571 |
| +2800 | 1.0e7 | 2.2e6 | 1.2e7 | 2.4e7 | .33 | .17 | .18 | 2.71 | 2.93 | 3063 |
| +3350 | 1.8e6 | 0 | 1.8e6 | 3.8e7 | .28 | .01 | .01 | .21 | .21 | 4000 |
| | | | | | 10.56 | 6.24 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGRIND FLOTATION TAILS #5142

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 3.7e5 | 8.7e5 | 1.2e6 | 1.6e6 | .04 | .03 | 2.93 | 1.06 | 100.00 | 53 |
| +75 | 5.7e5 | 1.7e5 | 7.4e5 | 2.2e6 | .13 | .04 | 2.90 | 1.51 | 98.94 | 126 |
| +212 | 8.8e5 | 1.6e6 | 2.5e6 | 5.5e6 | .27 | .12 | 2.85 | 4.12 | 97.43 | 300 |
| +425 | 4.7e5 | 1.2e6 | 1.6e6 | 4.1e6 | .17 | .07 | 2.73 | 2.28 | 93.30 | 505 |
| +600 | 2.8e6 | 5.4e6 | 8.2e6 | 1.2e7 | .6 | .40 | 2.66 | 13.59 | 91.02 | 714 |
| +850 | 4.4e6 | 7.0e6 | 1.1e7 | 1.5e7 | .53 | .39 | 2.27 | 13.43 | 77.44 | 922 |
| +1000 | 3.1e6 | 7.6e6 | 1.1e7 | 1.8e7 | .52 | .31 | 1.87 | 10.69 | 64.01 | 1086 |
| +1180 | 6.9e6 | 1.5e7 | 2.2e7 | 2.7e7 | .69 | .56 | 1.56 | 19.15 | 53.32 | 1285 |
| +1400 | 5.2e6 | 1.2e7 | 1.7e7 | 4.1e7 | .78 | .33 | 1.00 | 11.36 | 34.17 | 1543 |
| +1700 | 8.0e6 | 8.9e6 | 1.7e7 | 3.7e7 | .43 | .20 | .67 | 6.74 | 22.81 | 1844 |
| +2000 | 9.8e6 | 9.7e6 | 1.9e7 | 3.6e7 | .42 | .23 | .47 | 7.75 | 16.06 | 2173 |
| +2360 | 4.7e6 | 8.3e6 | 1.3e7 | 3.1e7 | .28 | .12 | .24 | 3.99 | 8.32 | 2571 |
| +2800 | 1.2e7 | 6.0e6 | 1.8e7 | 3.3e7 | .24 | .13 | .13 | 4.31 | 4.33 | 3063 |
| +3350 | 1.2e5 | 1.6e4 | 1.3e5 | 4.8e7 | .14 | .00 | .00 | .01 | .01 | 4000 |
| | | | | | 5.24 | 2.93 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

BALL MILL DISCHARGE #5143

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. | CUM. WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 4.8e5 | 9.8e5 | 1.5e6 | 1.7e6 | .01 | .01 | 5.47 | .15 | 100.00 | 53 | 100.00 | 9.14 |
| +75 | 2.5e6 | 3.7e6 | 6.2e6 | 7.6e6 | .11 | .09 | 5.46 | 1.64 | 99.85 | 126 | 99.90 | 9.13 |
| +212 | 4.1e6 | 1.3e7 | 1.7e7 | 2.3e7 | 1.71 | 1.24 | 5.37 | 22.69 | 98.21 | 300 | 98.76 | 9.02 |
| +425 | 5.2e6 | 8.6e6 | 1.4e7 | 2.0e7 | 1.08 | .76 | 4.13 | 13.89 | 75.52 | 505 | 80.16 | 7.31 |
| +600 | 4.2e6 | 4.5e6 | 8.7e6 | 1.9e7 | 1.39 | .64 | 3.37 | 11.66 | 61.63 | 714 | 67.42 | 6.23 |
| +850 | 3.3e6 | 8.1e6 | 1.1e7 | 1.8e7 | .74 | .47 | 2.73 | 8.52 | 49.97 | 922 | 47.36 | 4.84 |
| +1000 | 5.2e6 | 1.7e7 | 2.2e7 | 2.8e7 | 1.03 | .79 | 2.27 | 14.54 | 41.45 | 1086 | 36.71 | 4.10 |
| +1180 | 5.0e6 | 1.2e7 | 1.7e7 | 2.4e7 | .79 | .55 | 1.47 | 10.06 | 26.92 | 1285 | 27.61 | 3.07 |
| +1400 | 1.2e7 | 6.9e6 | 1.9e7 | 4.3e7 | .98 | .43 | .92 | 7.82 | 16.86 | 1543 | 19.95 | 2.28 |
| +1700 | 4.5e6 | 1.4e7 | 1.9e7 | 3.5e7 | .47 | .25 | .49 | 4.52 | 9.04 | 1844 | 11.74 | 1.30 |
| +2000 | 8.5e6 | 5.3e6 | 1.4e7 | 4.3e7 | .33 | .11 | .25 | 1.94 | 4.52 | 2173 | 7.89 | .83 |
| +2360 | 6.4e5 | 9.0e6 | 9.6e6 | 3.7e7 | .27 | .07 | .14 | 1.30 | 2.58 | 2571 | 4.42 | .50 |
| +2800 | 3.3e6 | 2.5e5 | 3.6e6 | 1.8e7 | .08 | .02 | .07 | .29 | 1.28 | 3063 | 2.23 | .23 |
| +3350 | 1.8e7 | 1.6e6 | 1.9e7 | 5.4e7 | .15 | .05 | .05 | .99 | .99 | 4000 | .86 | .15 |
| | | | | | 9.14 | 5.47 | | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

Liberation study for PCA mill samples collected August 28, 1987

ROUGHER FLOTATION FEED #5144

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS | CUM. GR. SIZE DIST. | CUM. WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 5.5e5 | 2.8e6 | 3.3e6 | 3.7e6 | .09 | .08 | 20.73 | .40 | 100.00 | 53 | 100.00 | 34.91 |
| +75 | 2.1e6 | 1.4e7 | 1.6e7 | 1.9e7 | .89 | .78 | 20.65 | 3.78 | 99.60 | 126 | 99.83 | 34.82 |
| +212 | 6.5e6 | 3.5e7 | 4.1e7 | 5.2e7 | 3.69 | 2.94 | 19.86 | 14.17 | 95.82 | 300 | 98.00 | 33.93 |
| +425 | 4.5e6 | 3.0e7 | 3.5e7 | 4.2e7 | 3.9 | 3.23 | 16.93 | 15.56 | 81.65 | 505 | 90.38 | 30.24 |
| +600 | 7.4e6 | 2.5e7 | 3.2e7 | 4.4e7 | 5.34 | 3.84 | 13.70 | 18.54 | 66.09 | 714 | 81.04 | 26.34 |
| +850 | 5.6e6 | 2.6e7 | 3.1e7 | 4.3e7 | 3.24 | 2.39 | 9.86 | 11.52 | 47.55 | 922 | 66.24 | 21.00 |
| +1000 | 3.8e6 | 1.8e7 | 2.2e7 | 3.4e7 | 2.72 | 1.72 | 7.47 | 8.30 | 36.03 | 1086 | 56.89 | 17.76 |
| +1180 | 5.8e6 | 1.2e7 | 1.8e7 | 3e7 | 2.5 | 1.49 | 5.75 | 7.16 | 27.73 | 1285 | 48.19 | 15.04 |
| +1400 | 1.7e7 | 1.5e7 | 3.2e7 | 5.3e7 | 3.54 | 2.13 | 4.26 | 10.26 | 20.57 | 1543 | 39.39 | 12.54 |
| +1700 | 3.7e6 | 1.2e7 | 1.6e7 | 3.9e7 | 2.23 | .91 | 2.14 | 4.39 | 10.31 | 1844 | 29.30 | 9.00 |
| +2000 | 2.3e6 | 7.5e6 | 9.9e6 | 4.4e7 | 2.22 | .50 | 1.23 | 2.41 | 5.92 | 2173 | 22.67 | 6.77 |
| +2360 | 1.0e7 | 6.6e5 | 1.1e7 | 5.1e7 | 1.87 | .40 | .73 | 1.93 | 3.52 | 2571 | 14.84 | 4.55 |
| +2800 | 3.1e6 | 5.2e6 | 8.3e6 | 3.6e7 | 1.24 | .29 | .33 | 1.39 | 1.58 | 3063 | 8.39 | 2.68 |
| +3350 | 1.9e4 | 1.3e6 | 1.4e6 | 4.9e7 | 1.44 | .04 | .04 | .19 | .19 | 4000 | 3.62 | 1.44 |
| | | | | 0 | 34.91 | 20.73 | | 100.00 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

BALL MILL FEED #5145

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 1.9e5 | 1.9e6 | 2.1e6 | 2.4e6 | .01 | .01 | 4.05 | .21 | 100.00 | 53 |
| +75 | 9.2e5 | 2.7e6 | 3.6e6 | 4.9e6 | .03 | .02 | 4.04 | .55 | 99.79 | 126 |
| +212 | 8.5e5 | 2.3e6 | 3.2e6 | 5.8e6 | .08 | .04 | 4.02 | 1.09 | 99.24 | 300 |
| +425 | 8.3e5 | 2.2e6 | 3.0e6 | 6.3e6 | .15 | .07 | 3.97 | 1.79 | 98.15 | 505 |
| +600 | 1.9e6 | 9.3e6 | 1.1e7 | 1.8e7 | .58 | .37 | 3.90 | 9.07 | 96.36 | 714 |
| +850 | 2.8e6 | 1.0e7 | 1.3e7 | 2.1e7 | .74 | .46 | 3.53 | 11.32 | 87.29 | 922 |
| +1000 | 2.4e6 | 7.2e6 | 9.7e6 | 1.5e7 | .83 | .54 | 3.07 | 13.47 | 75.97 | 1086 |
| +1180 | 4.1e6 | 1.0e7 | 1.4e7 | 1.9e7 | 1.02 | .79 | 2.53 | 19.43 | 62.50 | 1285 |
| +1400 | 2.4e6 | 9.1e6 | 1.1e7 | 3.0e7 | 1.5 | .57 | 1.74 | 14.13 | 43.07 | 1543 |
| +1700 | 1.2e7 | 1.9e7 | 3.1e7 | 5.5e7 | 1.18 | .65 | 1.17 | 16.14 | 28.95 | 1844 |
| +2000 | 1.0e7 | 6.2e6 | 1.7e7 | 4.2e7 | .85 | .33 | .52 | 8.24 | 12.81 | 2173 |
| +2360 | 8.4e6 | 1.2e6 | 9.6e6 | 3.5e7 | .65 | .18 | .18 | 4.40 | 4.57 | 2571 |
| +2800 | 0 | 0 | 0 | 3.1e7 | .38 | .00 | .01 | .00 | .17 | 3063 |
| +3350 | 0 | 5.3e5 | 5.3e5 | 1.9e7 | .24 | .01 | .01 | .17 | .17 | 4000 |
| | | | | | 8.24 | 4.05 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

ROUGHER FLOTATION CONCENTRATE #5146

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86% WT CUM | +86 % NORMALIZED | +86 CUM % | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.4e5 | 5.7e6 | 5.9e6 | 6.2e6 | .54 | .52 | 22.83 | 2.28 | 100.00 | 53 |
| +75 | 1.7e6 | 3.1e7 | 3.2e7 | 3.5e7 | 2.42 | 2.26 | 22.31 | 9.90 | 97.72 | 126 |
| +212 | 4.6e6 | 8.2e7 | 8.6e7 | 9.3e7 | 5.19 | 4.84 | 20.05 | 21.21 | 87.82 | 300 |
| +425 | 6.1e6 | 8.6e7 | 9.2e7 | 9.9e7 | 71X 5.31 | 4.94 | 15.21 | 21.63 | 66.62 | 505 |
| +600 | 2.2e7 | 9.4e7 | 1.2e8 | 1.3e8 | 5.85 | 5.38 | 10.27 | 23.55 | 44.99 | 714 |
| +850 | 1.1e7 | 9.7e7 | 1.1e8 | 1.1e8 | 2.13 | 2.02 | 4.90 | 8.86 | 21.44 | 922 |
| +1000 | 1.4e7 | 7.4e7 | 8.8e7 | 9.2e7 | 1.45 | 1.39 | 2.87 | 6.07 | 12.58 | 1086 |
| +1180 | 1.5e7 | 7.0e7 | 8.5e7 | 9.0e7 | .84 | .79 | 1.49 | 3.45 | 6.51 | 1285 |
| +1400 | 4.9e7 | 7.2e7 | 1.2e8 | 1.4e8 | .5 | .44 | .70 | 1.91 | 3.06 | 1543 |
| +1700 | 3.1e7 | 3.2e7 | 6.4e7 | 1.0e8 | .19 | .12 | .26 | .52 | 1.15 | 1844 |
| +2000 | 2.5e7 | 2.1e7 | 4.5e7 | 9.3e7 | .17 | .08 | .14 | .36 | .63 | 2173 |
| +2360 | 8.2e6 | 1.9e6 | 1.0e7 | 7.3e7 | .13 | .02 | .06 | .08 | .27 | 2571 |
| +2800 | 8.9e6 | 2.2e6 | 1.1e7 | 5.1e7 | .14 | .03 | .04 | .13 | .19 | 3063 |
| +3350 | 4.0e6 | 5.6e5 | 4.5e6 | 6.6e7 | .18 | .01 | .01 | .05 | .05 | 4000 |
| | | | | | 25.04 | 22.83 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

## PART 3: DENISON POTACAN POTASH MINE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# PART 3: DENISION POTACAN POTASH MINE

## 1.0 SUMMARY

Samples of ore, host rocks and salt horses, and a suite of mill samples were collected by Denision Potacan personnel. The composition, mineralogy and petrography of the rock samples was determined. The composition, grain size and liberation of the mill samples was determined. The mineralogy of the clays was examined.

The composition of the ore was variable across the sylvinite bed and no systematic variation was observed. The texture of the ore is a metamorphic texture and can be best described as gneissic. No original textures were observed in hand specimen, and very rarely were they observed microscopicaly, although in the mine large scale bedding features can be observed. The "gneissic" texture probably hinders liberation because grain boundaries are irregular and breakage across boundaries would result in ore mineral grains with inclusions of halite.

The microscopic textures of the salt horses demonstrate that the sylvite was replaced by the halite. The Br content of the salt horses is higher (average 250 ppm) than the bedded salt (less than 200 ppm), which indicates that the salt horses are not a depositional feature. This combined with the mapping of salt horses by the mine geologist demonstrate that they are channel ways in the sylvinite bed that have been replaced by halite.

The minerals identified in the clay rich areas were illite, kaolinite, chlorite, halloysite and K-feldspar. Many of the samples also contained an amorphous material. No expanding clays were identified, however some of the clays do expand as demonstrated by the expansion of clay layers when the samples are exposed to a humid environment. The presence of illite and feldspar suggest that the metamorphic grade of the deposit is lowest greenschist. Very little data are available on the kaolinite-illite-muscovite-feldspar system to allow for a more precise interpretation. The amorphous material may be responsible for the sliming problem that occurs intermittently.

Congolite a boron mineral which has an ideal formula $(Fe,Mg,Mn)_3(B_6O_9)BO_4Cl$ was extensively studied. Its presence is also suggestive of lower greenschist metamorphism.

A procedure was developed whereby the grind required for good liberation could be predicted from the chord length measurement of the grains in polished thin sections of ore samples. For 90% liberation the grind should have been 270 microns.

A set of mill samples were collected in June 1988. Liberation studies were preformed with automated image analysis. In all cases three main problems were identified; the grind was too coarse, the coarse grained liberated sylvite was not floating and some of the other liberated sylvite was not floating.

The main recommendation is that the grind should be finer and the grain size distribution be kept as narrow as possible. There should be no grains larger than 1000 microns. Another milling problem identified is the poor flotation of the liberated sylvite. Tests should be carried to solve this problem such as different reagents, changing the conditioning and residence time. Also, the observation was made by the mill personnel that the sylvite that doesn't float has a deep red colour. A preliminary mineralogical examination of the these grains did not detect chemical or physical differences from the sylvite that floated. A more extensive examination should be carried out.

The salt horses are a result of NaCl saturated brines which intrude the sylvinite unit and replaced the sylvite with halite. There are still several unanswered questions. What is the origin of the NaCl rich brines? When did the replacement occur; during diagenesis, during metamorphism, or during deformation? Is there a method other than mapping of predicting the location of the salt horses? Some of these questions might be answered through fluid inclusion studies and isotope studies.

The metamorphic grade of the deposit is still undefined and the expanding clays have not been identified. Further petrological work is required to solve these problems.

## 2.0 INTRODUCTION

Samples of ore and host rocks were collected from the mine and drill core. A suite of mill samples was collected in June 1988. A sample catalogue is given in Appendix A-1.

The mineralogy, petrography, grain size and chemical composition was determined for the rock samples. The grain size, liberation, mineral mode and chemical composition was determined for the mill samples.

# TROISIEME PARTIE: DENISON POTACAN POTASH MINE

## 1.0 RESUME

Des échantillons de minerai, de roches hôtes et de "salt horses", ainsi qu'une série d'échantillons de produits d'usine, ont été recueillis par le personnel de la Denison Potacan. La composition, la minéralogie et la pétrographie des échantillons de roches ont été déterminées. La composition, la grosseur du grain et la libération des échantillons de produits d'usine ont été déterminées. La minéralogie de l'argile a été examinée.

La composition du minerai variait dans le lit de sylvinite et aucune variation systématique n'a été observée. Le minerai a une texture métamorphique qui peut être qualifiée surtout de gneissique. Aucune texture originale n'a été observée chez les spécimens macroscopiques; on en a très rarement observé de façon microscopique, bien que des caractéristiques de stratification à grande échelle puissent être observées dans la mine. La texture "gneissique" entrave probablement la libération puisque les contours du grain sont irréguliers et que la rupture des contours entraînerait des minéraux métalliques remplis d'intercalations.

Les textures microscopiques des "salt horses" démontrent que la sylvine a été remplacée par le sel gemme. La teneur des "salt horses" est supérieure (en moyenne 250 ppm) à celle du sel stratifié (moins de 200 ppm), ce qui indique que les "salt horses" ne sont pas propres à la sédimentation. Combiné à la représentation sur carte des "salt horses" par les géologues de la mine, cela démontre que ce sont des canaux dans le lit de sylvinite où la sylvine a été remplacée par le sel gemme.

Les minéraux identifiés dans les régions riches en argile sont l'illite, le kaolinite, le chlorite, l'halloysite et le feldspath potassique. Bon nombre de ces échantillons contiennent également un matériau amorphe. Aucune argile expansive n'a été identifiée; toutefois, certaines argiles prennent de l'expansion tel qu'il est démontré par l'expansion des couches d'argile lorsque les échantillons sont exposée à un environnement humide. La présence d'illite et de feldspatch suggère que la qualité métamorphique du gisement est

du schiste vert inférieur. Peu de données sont disponibles au sujet du système kaolinite-illite-muscovite-feldspath pour permettre une interprétation plus précise. Le matériau amorphe peut être la cause du problème de surbroyage qui survient de façon intermittente.

Le congolite, un minéral de bore possédant une formulation idéale $(Fe, Mg, Mn)_3(B_6O_9)BO_4Cl$ a été étudié de façon exhaustive. Sa présence suggére également un métamorphisme de schiste vert inférieur.

Une méthode a étét mise au point afin que le broyage nécessaire pour une bonne libération soit prévu à partir de la longueur de la corde des grains comme point de référence, dans de minces sections polies d'échantillons de minerai. Pour 90% de libération, le broyage aurait dû être de 270 microns.

Une série d'échantillons de produits d'usine a été prélevée en juin 1988. Des études de libération ont été effectuées par analyse d'image automatisée. Dans tous les cas, trois principaux problèmes ont été identifiés: le minerai broyé était trop gros, la sylvine libérée à gros grains ne flottait pas et quelques-unes des autres sylvines ne flottaient pas.

La principale recommandation préconise que le broyage soit plus fin et que la distribution de la grosseur du grain soit maintenue aussi étroite que possible. Il ne devrait pas y avoir de grains d'une grosseur supérieure à 1000 microns. Un autre problème de broyage identifié est la faible flottation de la sylvine libérée. Des essais devraient être effectués pour résoudre ce problème, tels que l'utilisation de différents réactifs, la modification du temps de conditionnement et de séjour. Le personnel de l'usine a également fait remarquer que la sylvine qui ne flotte pas a une couleur rouge foncé. Un examen minéralogique préliminaire de ces grains n'a révélé aucune différence chimique ou physique par rapport à la sylvine qui flotte. Un examen plus détaillé devrait être entrepris.

Les "salt horses" sont un résultat des saumures saturées du NaCl qui étaient introduites dans l'unité de sylvine et remplacées dans la sylvine avec l'halite. Plusieurs questions demeurent toujours sans réponse. D'où proviennent les saumures riches du

NaCl? Quand le remplacement a-t-il eu lieu? Pendant le diagnostic, la métamorphose ou la déformation? Y a-t-il une méthode autre que la représentation sur carte pour prédire l'emplacement des "salt horses"? On peut répondre à certaines de ces questions par des études d'inclusion fluide et d'isotope.

La qualité métamorphique du gisement n'est toujours pas défini et l'argile expansive n'a pas été identifiée. D'autres travaux pétrologiques sont nécessaires pour résoudre ces problèmes.

## 3.0 GEOCHEMISTRY OF THE ORE SAMPLES

The chemical composition of the rock samples collected is given in Table 1. The samples analyzed include samples of ore, salt horses, marker beds, halite units, and anhydrite-halite units. The composition of the ore varies from 12 to 46 Wt% K and no systematic changes across the sylvinite bed was observed. It was hoped that there would be a chemical indicator that would help locate salt horses. None was found. The changes from ore to horse is chemically as sharp as the geographic contact. The Br composition of the rocks did lead to an understanding of the genesis of the salt horses and it will be discussed in detail later.

# TABLE 1

TABLE CHEMICAL ANALYSIS OF POTACAN ORE SAMPLES

| DESCRIPTION | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE | ORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5051 | 5052 | 5053 | 5054 | 5055 | 5056 | 5057 | 5058 | 5059 | 5060 | 5061 | 5062 | 5063 | 5064 |
| WT% | | | | | | | | | | | | | | |
| K | 18.38 | 2.25 | 14.93 | 25.92 | 20.43 | 18.72 | 21.43 | 15.31 | 22.64 | 3.97 | 3 | 46.02 | 20.39 | 27.98 |
| CA | .25 | .36 | .21 | .10 | .15 | .23 | .28 | .38 | .18 | .26 | 0 | .07 | .20 | .14 |
| NA | 21.83 | 33.49 | 23.91 | 15.86 | 19.89 | 21.24 | 21.11 | 25.98 | 22.07 | 36.06 | 34 | 8.43 | 22.15 | 17.91 |
| CL | 51.10 | 53.00 | 50.25 | 48.15 | 49.20 | 50.30 | 51.20 | 54.35 | 54.05 | 59.15 | 56 | 54.8 | 53.15 | 52.55 |
| SO4 | .45 | .70 | .50 | .17 | .47 | .29 | .33 | .55 | .28 | .38 | 0 | .05 | .32 | .22 |
| INSOLUBLES | 7.87 | 8.99 | 4.10 | 7.55 | 5.83 | 3.95 | 4.80 | 3.21 | 5.95 | <.5 | 6 | | 2.09 | <.05 |
| PPM | | | | | | | | | | | | | | |
| MG | 365 | 318 | 474 | 314 | 394 | 427 | 443 | 429 | 536 | 231 | 197 | 189 | 300 | 280 |
| FE | 298 | 977 | 207 | 426 | 316 | 242 | 542 | 530 | 691 | 102 | 144 | 115 | 174 | 357 |
| MN | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| ZN | 12 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 18 | <10 | 23 | 28 | 21 | 11 |
| BR | 400 | 155 | 379 | 1060 | 719 | 919 | 635 | 582 | 706 | 250 | 213 | 1012 | 920 | 1029 |
| SR | 13 | 19 | 12 | <10 | 10 | 6 | <10 | 12 | <10 | <10 | <10 | 16 | 14 | 17 |
| RB | 22 | <10 | 24 | 7 | 15 | 24 | 25 | 21 | 5 | 18 | 25 | 43 | 31 | 38 |
| B | 5 | 2 | 8 | <2 | 7 | 3 | 1 | 4 | 4 | <2 | <2 | <2 | 6 | <2 |
| TOTAL | 99.54 | 98.24 | 93.51 | 97.76 | 95.65 | 94.60 | 98.98 | 99.39 | 105.09 | 99.50 | 99.25 | 109.46 | 98.13 | 98.75 |
| NORM | | | | | | | | | | | | | | |
| SYLVITE K | 35.04 | 4.29 | 28.47 | 49.42 | 38.95 | 35.69 | 40.86 | 29.19 | 43.17 | 7.57 | 6 | 87.745 | 38.88 | 53.35 |
| HALITE NA | 55.49 | 85.13 | 60.78 | 40.32 | 50.56 | 53.99 | 53.66 | 66.04 | 56.10 | 91.67 | 87 | 21.429 | 56.31 | 45.53 |
| ANAL. CL | 51.10 | 53.00 | 50.25 | 48.15 | 49.20 | 50.30 | 51.20 | 54.35 | 54.05 | 59.15 | 56 | 54.8 | 53.15 | 52.55 |
| CAL. CL | 50.33 | 53.68 | 50.41 | 47.96 | 49.19 | 49.73 | 51.98 | 53.94 | 54.56 | 59.21 | 56 | 54.725 | 52.64 | 52.99 |
| ANHYDRITE | .85 | 1.22 | .71 | .34 | .51 | .78 | .95 | 1.29 | .61 | .88 | 1 | .23778 | .68 | .48 |
| CAL SO4 | .60 | .86 | .50 | .24 | .36 | .55 | .67 | .91 | .43 | .62 | 1 | .16778 | .48 | .34 |
| INSOLUBLES | 7.87 | 8.99 | 4.10 | 7.55 | 5.83 | 3.95 | 4.80 | 3.21 | 5.95 | .00 | 6 | 0 | 2.09 | .00 |
| NORM TOTAL | 99.26 | 99.64 | 94.06 | 97.63 | 95.85 | 94.42 | 100.27 | 99.73 | 105.83 | 100.12 | 100 | 109.41 | 97.95 | 99.35 |

| DESCRIPTION | ORE | ORE | ORE | ORE | ORE | BARREN | BARREN |
|---|---|---|---|---|---|---|---|
| SAMPLE | 5065 | 5066 | 5067 | 5068 | 5069 | 5070 | 5071 |
| WT% | | | | | | | |
| K | 24.19 | 18.20 | 21.19 | 30.98 | 26.21 | 1.38 | .71 |
| CA | .19 | .25 | .22 | .15 | .16 | .38 | .35 |
| NA | 21.47 | 23.94 | 22.71 | 16.27 | 19.24 | 35.46 | 34.72 |
| CL | 55.35 | 53.80 | 54.58 | 53.30 | 53.70 | 56.35 | 54.75 |
| SO4 | .23 | .34 | .43 | .22 | .27 | .70 | .72 |
| INSOLUBLES | <.05 | 1.95 | <.05 | <.05 | <.05 | 4.04 | 8.11 |
| PPM | | | | | | | |
| MG | 400 | 189 | 294 | 558 | 307 | 860 | 463 |
| FE | 557 | 500 | 528 | 655 | 326 | 382 | 411 |
| MN | <10 | <10 | <10 | 6 | <10 | <10 | <10 |
| ZN | 16 | 26 | 21 | 27 | 24 | 6 | 22 |
| BR | 1043 | 768 | 905 | 1203 | 1021 | 230 | 181 |
| SR | 15 | 20 | 10 | 13 | <10 | 16 | 12 |
| RB | 25 | 17 | 21 | 28 | 29 | <10 | <10 |
| B | 3 | 1 | 3 | 4 | <2 | 4 | 1 |
| TOTAL | 101.41 | 98.29 | 98.88 | 100.95 | 99.48 | 97.76 | 98.75 |
| NORM | | | | | | | |
| SYLVITE K | 46.12 | 34.70 | 40.40 | 59.07 | 49.97 | 2.63 | 1.35 |
| HALITE NA | 54.58 | 60.86 | 57.73 | 41.36 | 48.91 | 90.14 | 88.26 |
| ANAL. CL | 55.35 | 53.80 | 54.58 | 53.30 | 53.70 | 56.35 | 54.75 |
| CAL. CL | 55.04 | 53.42 | 54.23 | 53.18 | 53.43 | 55.93 | 54.18 |
| ANHYDRITE | .65 | .85 | .75 | .51 | .54 | 1.29 | 1.19 |
| CAL SO4 | .46 | .60 | .53 | .36 | .38 | .91 | .84 |
| INSOLUBLES | .00 | 1.95 | .00 | .00 | .00 | 4.04 | 8.11 |
| NORM TOTAL | 101.35 | 98.36 | 98.88 | 100.94 | 99.43 | 98.10 | 98.91 |

# 4.0 MINERALOGY OF THE ORE SAMPLES

## 4.1 Sylvite and Halite; Texture and Grain Size

The halite and sylvite are usually completely recrystallized and deformed. The only primary textures observed are the relict hopper crystals which are identified by the "hopper" type distribution of fluid inclusions and fine-grained distribution of minute anhydrite crystals in discontinuous layers in sylvite and halite crystals. Negative crystal fluid inclusions are abundant. The texture is metamorphic and is best described as gneissic. Other accessory minerals are anhydrite, clays (which will be discussed in Section 4.2), Fe oxides, pyrite, and carbonates. Figure 1 is a backscattered electron of the typical of sylvinite.

The highly irregular grain boundaries will probably cause a problem in achieving good liberation. The rock is more likely to fracture along crystal cleavage planes than along grain boundaries, thereby causing the entrapment of small sized particles in mineral grains.

The size distribution of the sylvite is given in Figure 2. The grain size varies from 4000 microns to 40 microns. For 90% liberation the optimum grind is predicted as 270 microns.

## 4.2 Clay Minerals

The results are summarized in Table 2. The areas of clay usually contain quartz, illite, muscovite, kaolinite, Fe-chlorite and a K-feldspar in addition to halite, sylvite and anhydrite. The identification of the minerals was confirmed by qualitative microprobe analysis.

The presents of this assemblage of minerals is suggestive of a low greenschist metamorphic grade, however a more presice constraint is not possible because the

stability fields have not been delineated (Brindley and Brown, 1980 and Srodon, 1984). The K-feldspar is suggestive of higher metamorphism, however diagenetic feldspar has been documented by Walker et al 1978.

No expanding clays were found, however the clay rich layers in the evaporite sequence do expand when exposed to humid conditions. For example, when a polished block of sylvinite which contains a clay rich layer was left exposed to the atmosphere for several weeks during a period of high humidity, the clay rich layers protruded out from the surface. It might be possible that the anhydrite, which occurs in most clay layers, is hydrated to gypsum which would cause the expansion. Gypsum was found in only one sample, however an amorphous phase was found in several samples. When examined with the electron microscope the material was composed of Ca and S and is probablely a hydrated amorphous $CaSO_4$. More work is required to establish with certainty the cause of the expanding layers.

## 4.3 Boron Minerals

The boron minerals were studied in detail by Peter Burns, a student at UNB, as an undergraduate thesis project (Burns 1988). The microprobe analyses were performed at RPC, and the XRD analyses and interpretation were made at UNB. The boron minerals were extracted from Sample No. 5120 and 5121, Upper Halite. The minerals were identified as Mg-congolite (the type specimen contains only 0.24 Wt% Mg) with a bulk composition of $Mg_{2.21}Fe_{0.74}Mn_{0.03}[B_6O_9]BO_4Cl_{1.03}$ for sample 5120 and $Mg_{2.36}Fe_{0.64}Mn_{0.02}[B_6O_9]BO_4Cl_{1.03}$ for sample 5121, and they contain rhombohedral, space group R3c and cubic phases. Mg, Mn and Fe zoning occur in all samples. The pentaborate hilgardite $Ca_2[B_5O_9]Cl.H_2O$ was identified by XRD in sample 5120.

Although, no published stability data were available for this composition. The upper stability temperature for rhombohedral end member congolite is $247^0$ C. The inversion to the cubic form is approximately $300^0$ C. Again this suggests a lower greenschist metamorphic grade.

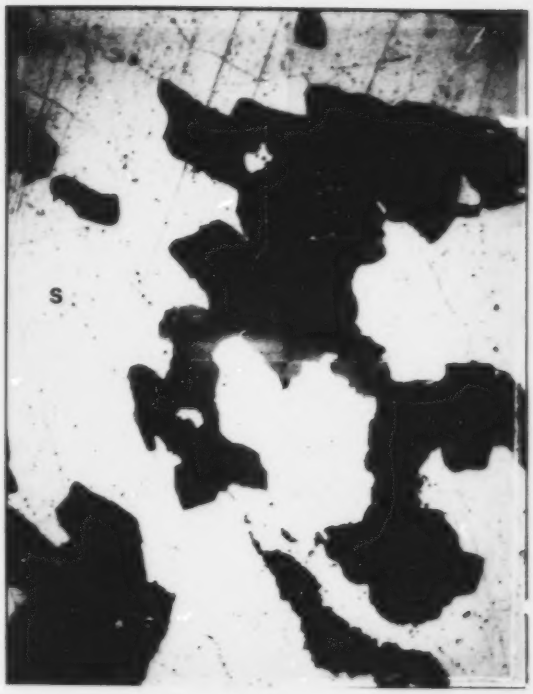



**FIGURE 1** Typical texture of potash ore. Halite (H) and Sylvite (S).

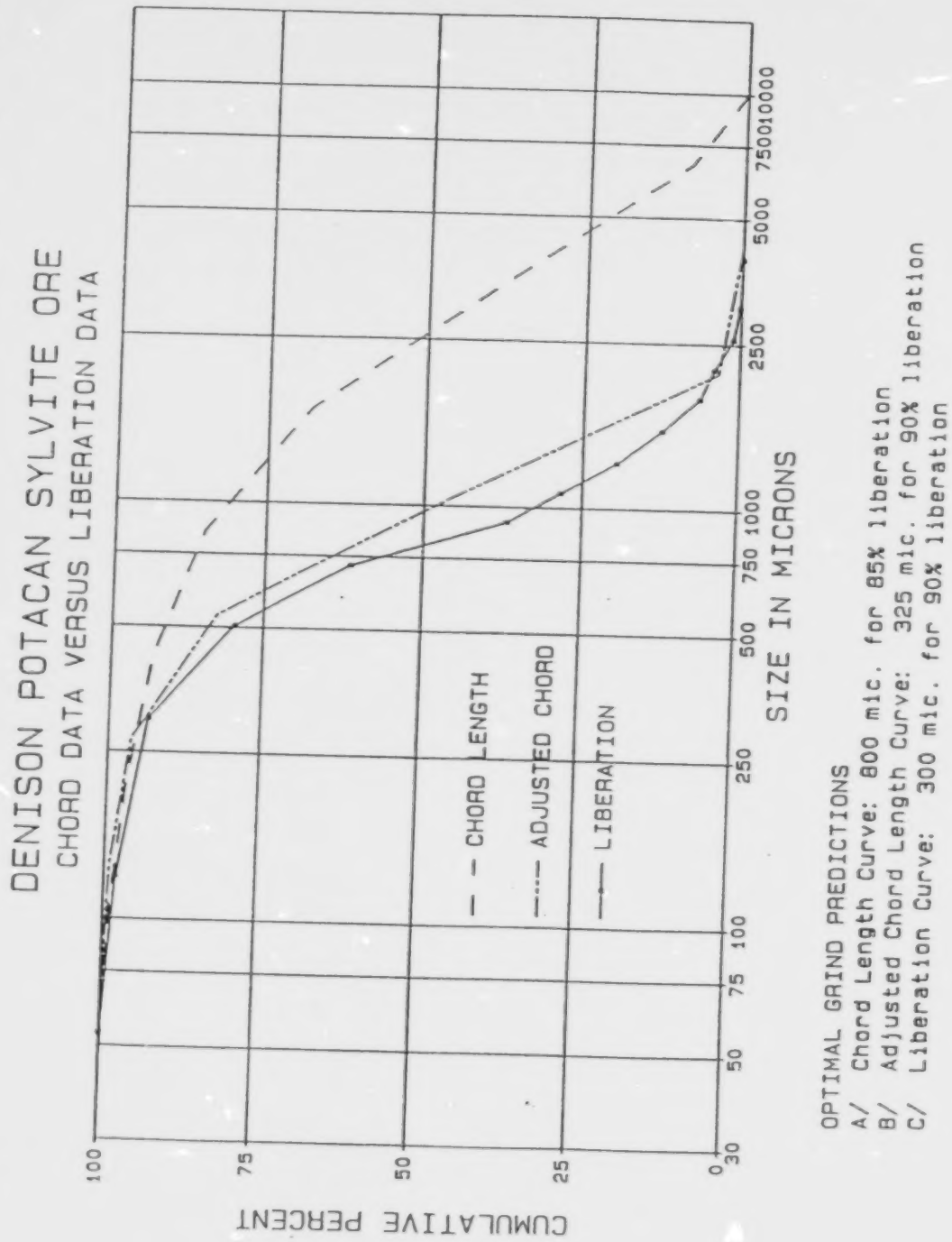



**FIGURE 2** Comparison of the cumulative liberation curve of the rougher concentrate and the cumulative chord length measurements for an unbroken ore sample.

**TABLE 2**

**The clay and associated minerals of samples collected from the Denison Potacan mine.**

| Sample No. | Minerals |
|---|---|
| 5106 | Halite, Quartz, Sylvite, Na-illite, Kaolinite, Mg-chlorite, Calcite, Dolomite, and Palygorskite ? |
| 5105 | Anhydrite, Quartz, Illite, Mg-chlorite, Halite, Monoclinic K-spar, Albite, Palygorskite ? |
| 5193 Grey-green E-zone Upper-Halite | Fe-chlorite, Halloysite, Kaolinite, Quartz, Albite approximately 12% Or., Anhydrite, Halite, Sylvite |
| 5194 Grey-green E-zone Upper-Halite | Na-muscovite, Fe-chlorite, Halloysite, Kaolinite, Anhydrite, Quartz, Halite, Sylvite |
| 5195 Orange E-zone Upper-Halite | Na-muscovite, Fe-Chlorite, Halloysite, Kaolinite, Quartz, Sylvite, Halite |

## 5.0 SALT HORSES

Salt horses or barren zones are areas within the potash ore that are predominately halite. The salt horses vary in size, location and extent. Underground mapping carried out by the mines has indicated that they are formed by a replacement mechanism after the deposition of the sylvinite beds. From a mining point of view, it is important to be able to predict and map these areas. Therefore, a knowledge of the genesis of the salt horses would greatly aid in this endeavour. PCA and Denison Potocan have agreed to combined the data for this study. A preliminary report was given at the 1988 Current Research Session at the annual meeting of the Atlantic Geoscience Society (Stirling et al 1988).

During the project samples of ore, host rocks and salt horses were collected by the mine geologists. The samples were chemically analyzed, examined petrographically and six samples were selected for microprobe analyses of halite and sylvite.

The concentration of the Br in the ore increases with K to maximum of 1200 ppm, in the stratigraphic halite it is less than 200 ppm, and in the barren zones it is between 200 and 300 ppm (Figure 3). This indicates that the same processes did not form the stratigraphic halite and the salt horses.

After the whole rock data were compiled, the Br content of sylvite and halite minerals was determined by electron microprobe analysis. The results are given graphically for individual samples in Figure 4, Figure 5 is the average for each rock type and the original data is given in Appendix A-2.

The concentration of Br in the halite from the stratigraphic halite Sample 5023 Figure 4a is the lowest , <200 ppm as would be expected from the whole rock data. The concentration of Br halite from the ore varies from not detected to 700 ppm (Figures 4 b, d and e) and from salt horses up to 500 ppm (Figures 4 c and f). The concentration of Br in the sylvite varies from 500 to 4000 ppm (Figures 4 b, c, d, e and f).

The large variation in the Br concentration for sylvite and halite in the sylvinite is probably a reflection of the changing concentration of the Br concentration in the original brine as crystallization proceeded. For example as the brine became more concentrated the amount of Br partitioned to halite (Herrmann 1980) and sylvite would increase (Stoessell and Carpenter 1986). Also the brine composition could change by an influx of fresh water (Stirling et al 1983).

The sylvinite beds should be considered as accumulates in that the salt crystals can form on the brine surface and when they reach a certain size they sink to the bottom. Therefore, the accumulated crystals did not necessarily form in the same chemical environment.

Textural the halite replaces the sylvite (Figures 6 to 9). The sylvite is interstitial to halite, usually has embayment cusps and narrow spines into the halite. Often the clay minerals are between larger halite grains as though the halite, as it crystallized pushed the clays to the grain boundaries. The salt horses usually have more fluid inclusions than the other units.

After the diagenesis of the evaporate sequence, salt horses formed when NaCl saturated brine intruded the sylvinite bed dissolving sylvite (thereby increasing the Br concentration of the brine) and precipitating halite which has a higher Br concentration than the stratigraphic halite. The origin of the brine is uncertain. A similar model for barren halite zones at Carlsbad was developed by Linn and Adams 1961, and at Esterhazy by Mcintosh and Wardlaw (1968).

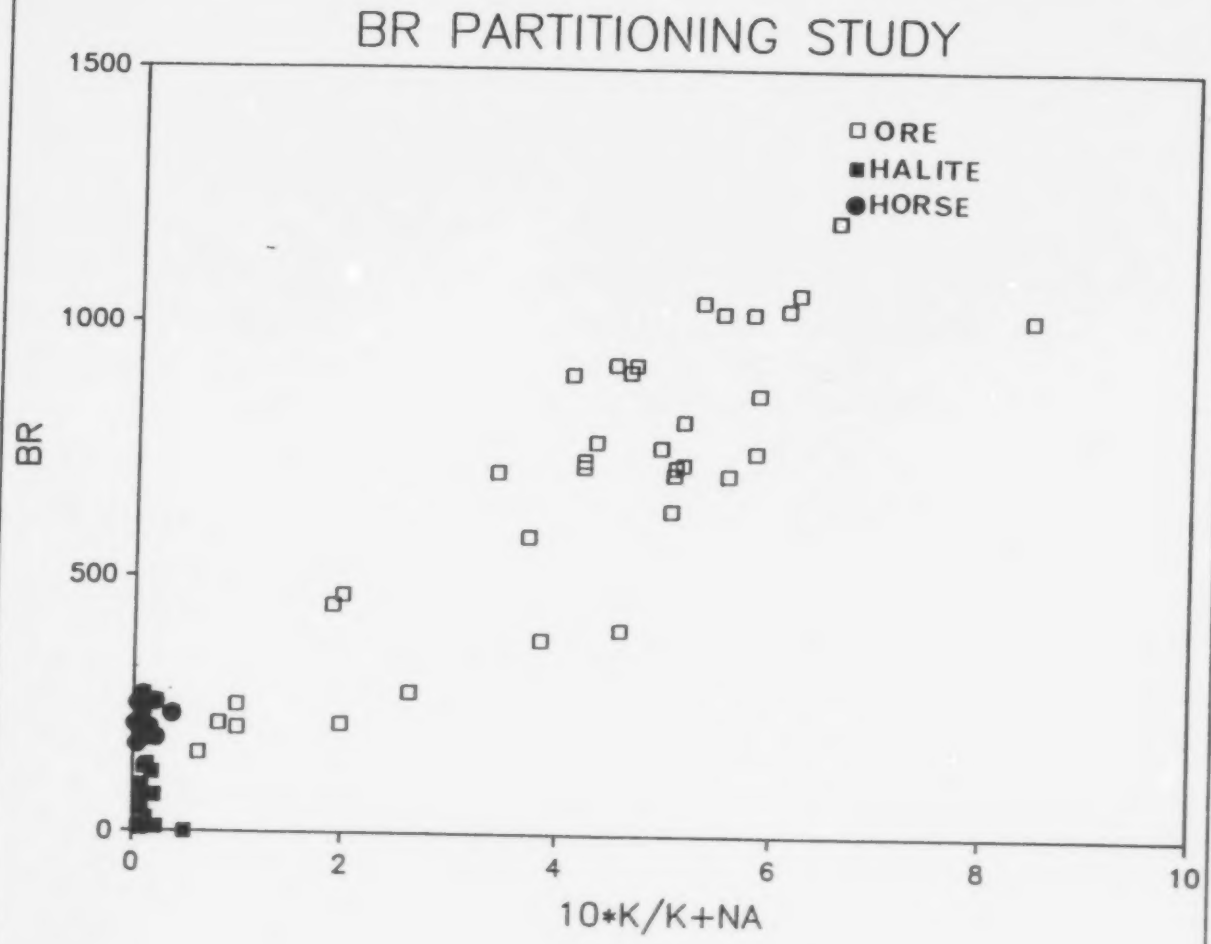



**FIGURE 3** Br content of salt horses as compared to stratigraphic halite and potash ore.

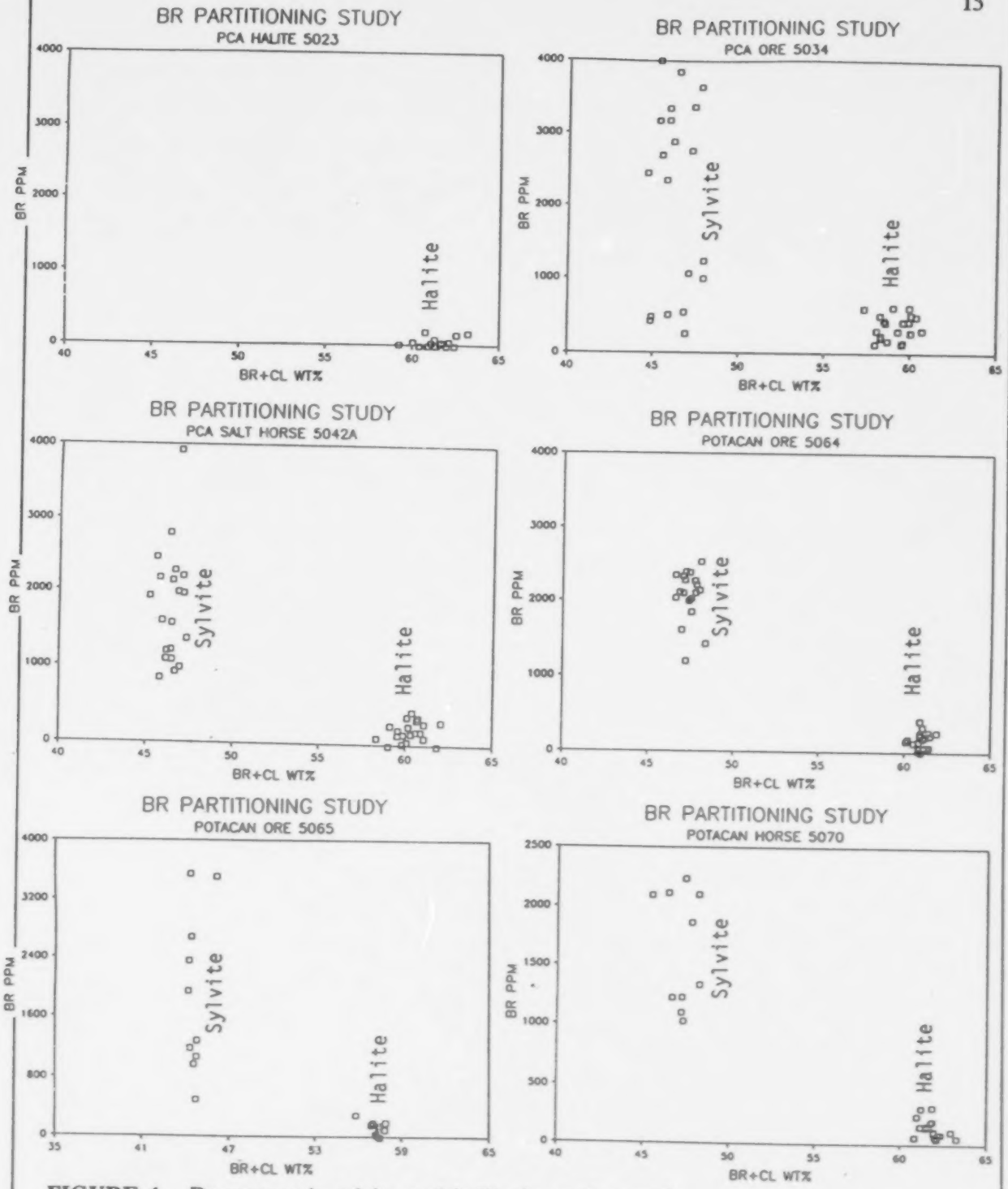



**FIGURE 4** Br content in sylvite and halite for each sample.

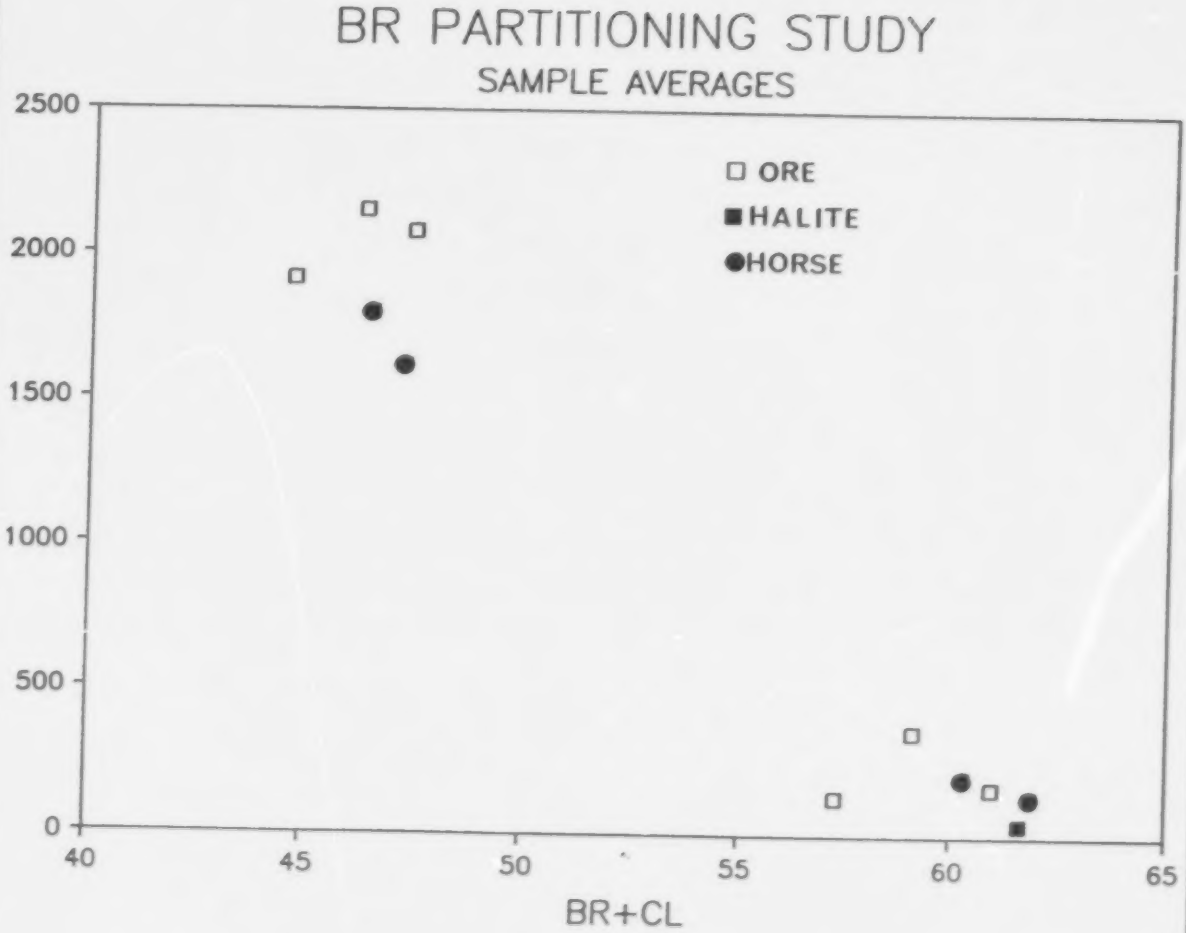



**FIGURE 5** Average Br content for halite and sylvite for each rock type.

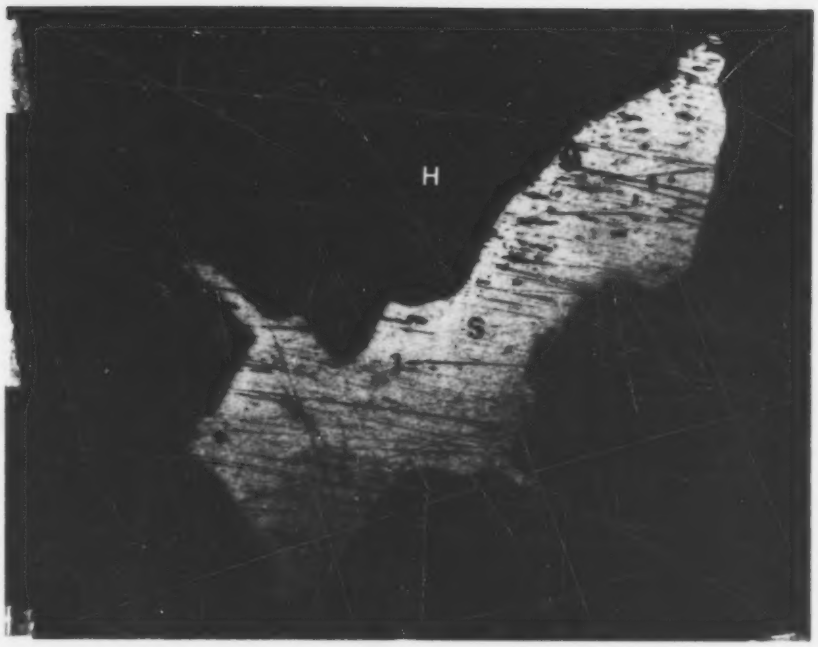



**FIGURE 6** Replacement of sylvite (S) by halite (H). Salt horse sample from PCA, RPC #5042.

**FIGURE 7** Remnant sylvite (S) grain in halite (H). The embagment cusps are typical replacement tetures. Salt horse sample from PCA, RPC #5042. The white bar equals 1 mm.

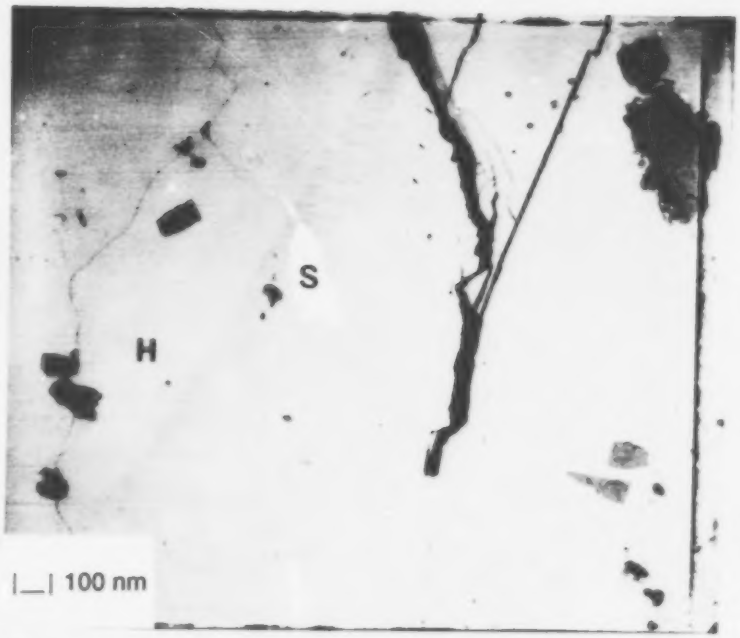



**FIGURE 8** Barren halite (H) zone with anhydrite (A) and remnant sylvite (S) in halite. The white bar equals 100 microns.

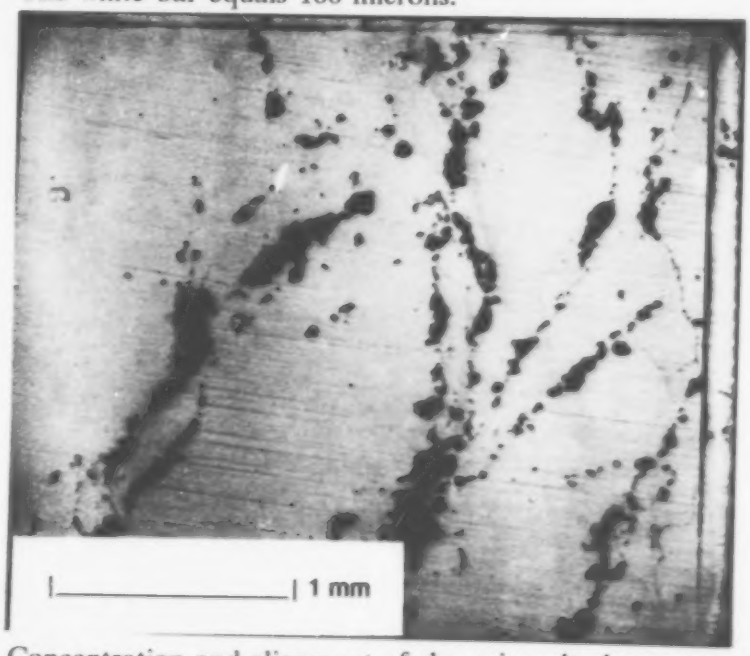



**FIGURE 9** Concentration and alignment of clay minerals about composite halite grains. Black areas are clays, dark area is halite and the white areas ae Fe oxides. The white bar equals 1 mm.

## 6.0 EVALUATION OF THE DENISON POTACAN CIRCUIT FOR SAMPLES COLLECTED JUNE 8, 1988

A suite of mill samples were collected by Denison Potacan personnel on June 8, 1988. The mill flow sheet is given in Appendix A-3. A list of the samples collected and the mill balance is given in Table 3. The chemical analyses of the ore samples is given in Appendix A-4 and the sieve analysis and liberation data is given in Appendix A-5.

The liberation curves and weighted modal mineralogy of the coarse rougher flotation circuit is given in Figure 10. The grind and the predicted grind are the same (d80 225 microns), however the grain size distribution is too wide. The grain size curve for the grind should be steeper. Much of the coarse liberated sylvite is reporting to the tails. At 1000 microns equal amounts (2.0%) of liberated sylvite are in both the tails and the concentrate(Figure 11). For the material finer than 1000 microns, nearly all of the liberated sylvite reports to the concentrate, as demonstrated by the nearly flat cumulative curve for the tails (Figures 10 and 11).

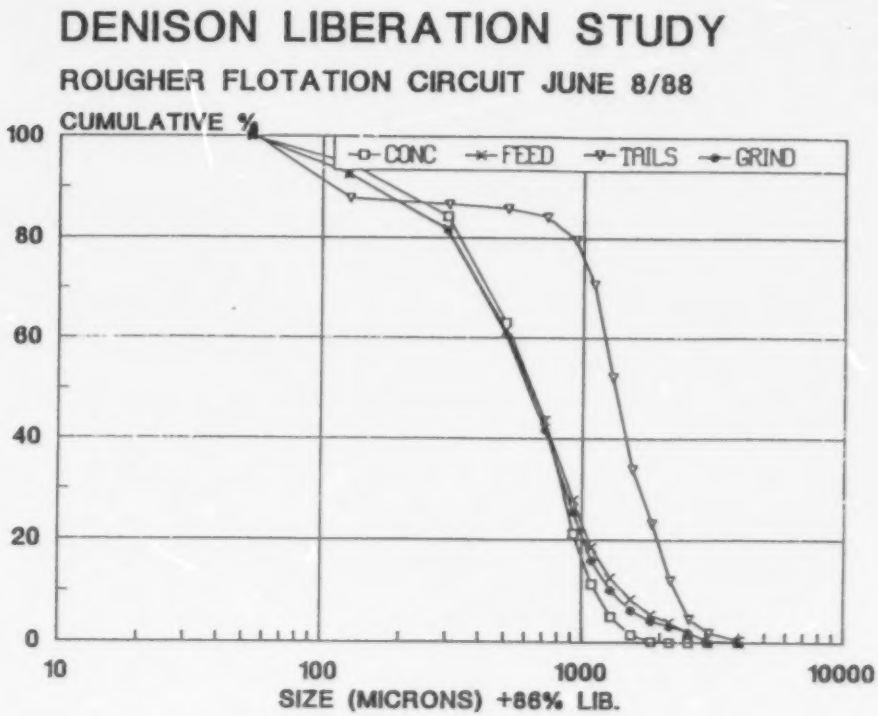
The coarse material goes to a regrind circuit where it is reduced to a d80 of 200 microns, however, the grain size distribution is too wide; approximately 20% of the feed is coarser than 1000 microns (Figure 12) which represents 1.0% of the available sylvite (Figure 13). In this circuit some of the coarse liberated sylvite reports to the tails and also some of the fine liberated sylvite reports to the tails.

The feed for the fines rougher flotation circuit has a d80 of approximately 180 microns, however less than 5.0% of the ore is greater than 1000 microns (Figure 14). Very little of the liberated sylvite reports to the tails (Figure 14b and 15).

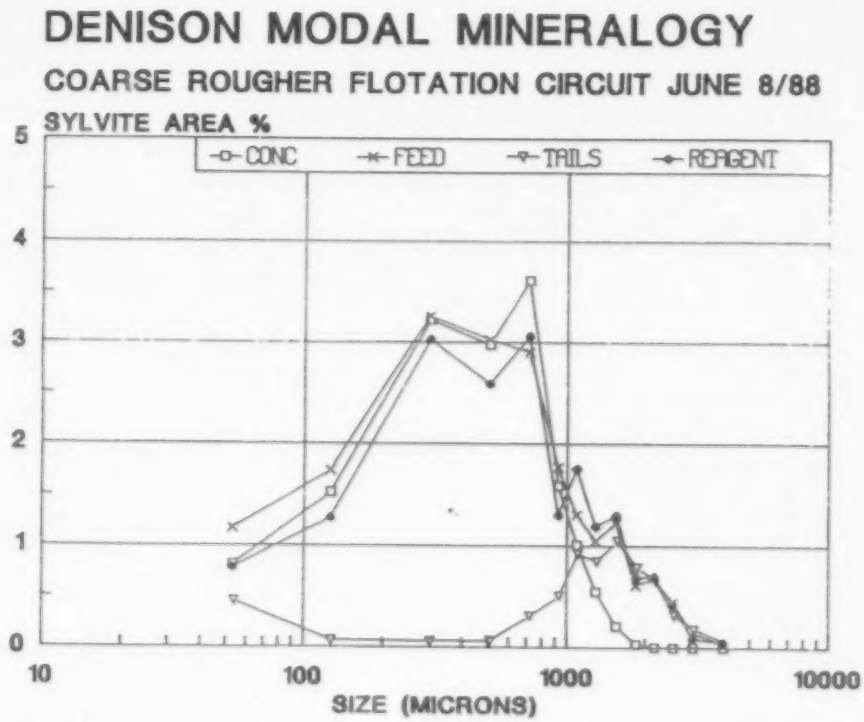
**TABLE 3**

**Samples collected from the Denison Potacan mill and the mill balance.**

| RPC No. | Description | Tonnes/Hr. | Mill Balance |
|---|---|---|---|
| | Mill Feed | 449.0 | 100% |
| 5200 | Reagent Drum Discharge | 238.0 | 53% |
| | Recleaner Tails | 4.4 | 1% |
| 5199 | Coarse Flotation Feed | 242.4 | 54% |
| 5201 | Coarse Flotation Concentrate | 75.3 | 17% |
| 5202 | Coarse Flotation Tails | 167.1 | 37% |
| 5203 | Fines Flotation Feed | 184.2 | 41% |
| 5204 | Fines Flotation Concentrate | 86.5 | 19% |
| 5205 | Fines Flotation Tails | 97.7 | 22% |
| 5206 | Regrind Flotation Feed | 165.0 | 37% |
| 5207 | Regrind Flotation Conc. | 30.8 | 7% |
| 5208 | Regrind Flotation Tails | 134.2 | 30% |




A




B

**FIGURE 10** Liberation curves (A) and weighted modal mineralogy (B) for the coarse rougher flotation circuit. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

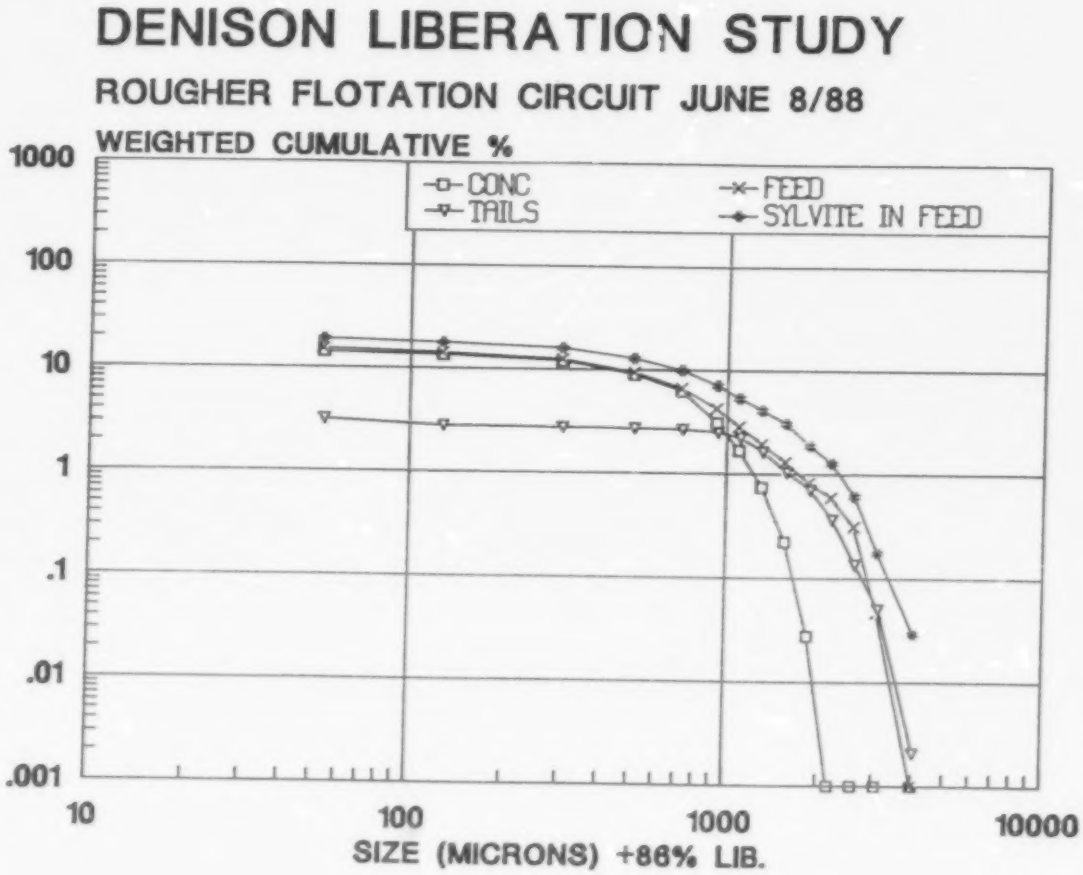
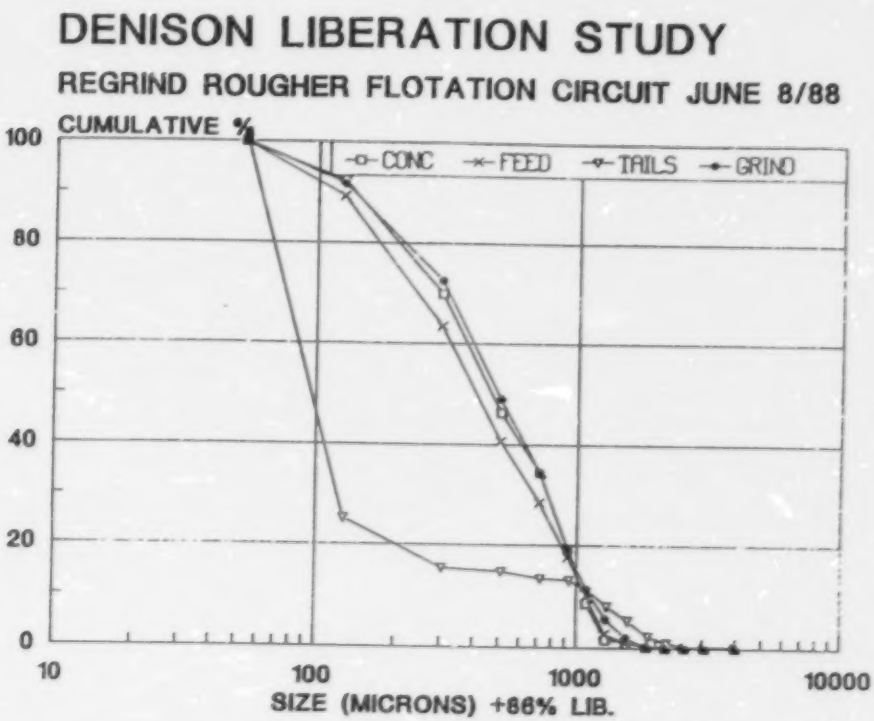
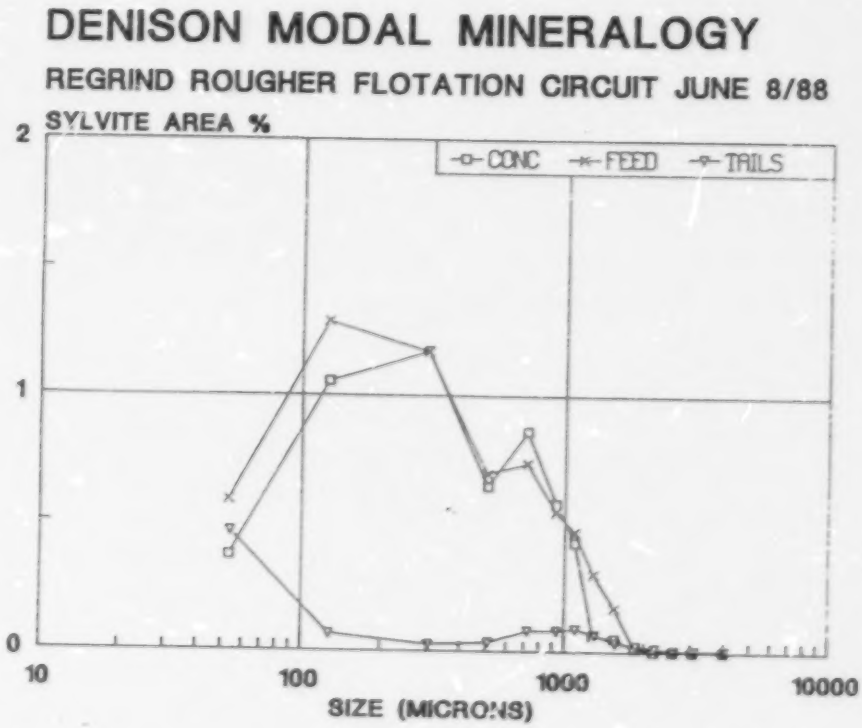



**FIGURE 11** Weighted liberation curves for the coarse rougher flotation circuit. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.




A




B

FIGURE 12 Liberation curves (A) and weighted modal mineralogy (B) for the regrind rougher flotation circuit. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

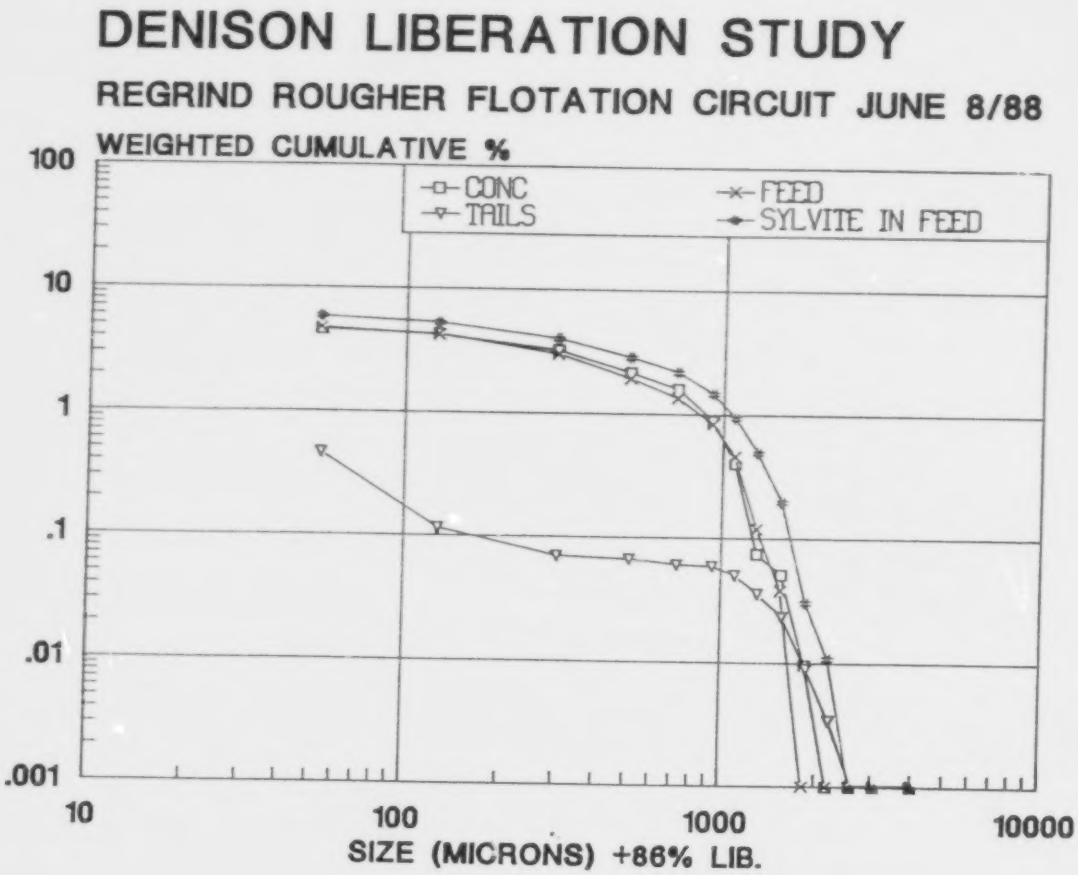
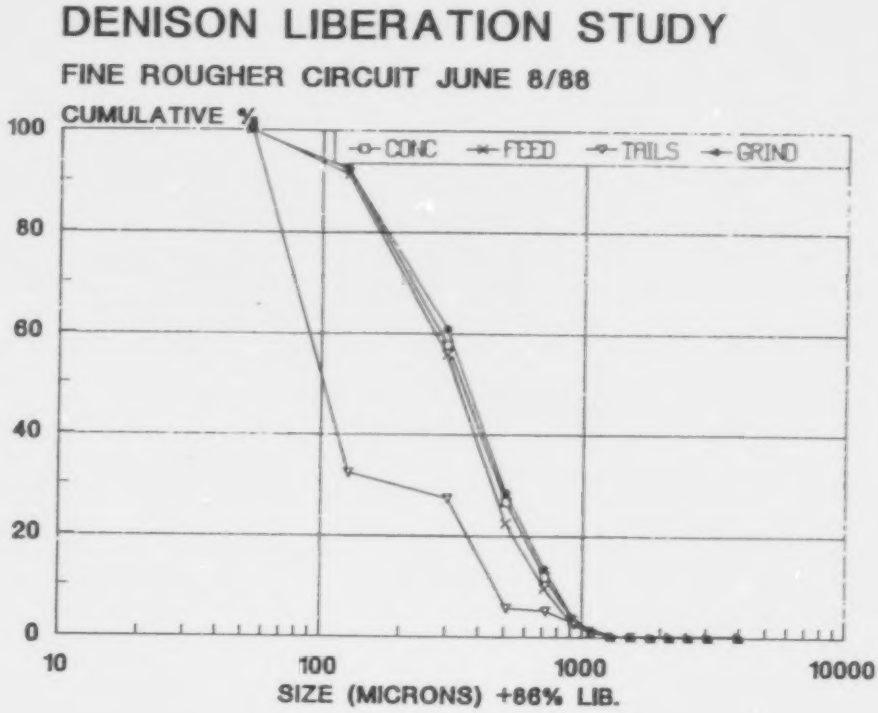
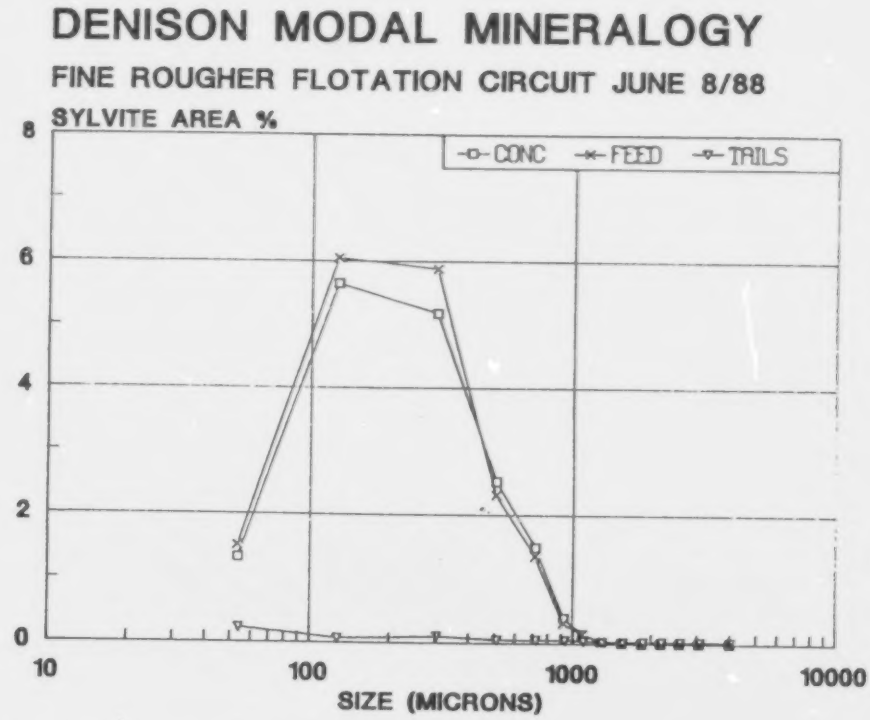



**FIGURE 13** Weighted liberation curves for the regrind rougher flotation circuit. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.




A




B

**FIGURE 14** Liberation curves (A) and weighted modal mineralogy (B) for the fines rougher flotation circuit. The grind curve in Figure A is the accumulated grain size of the rougher feed. In Figure B, the modal mineralogy is weighted by the mill balance.

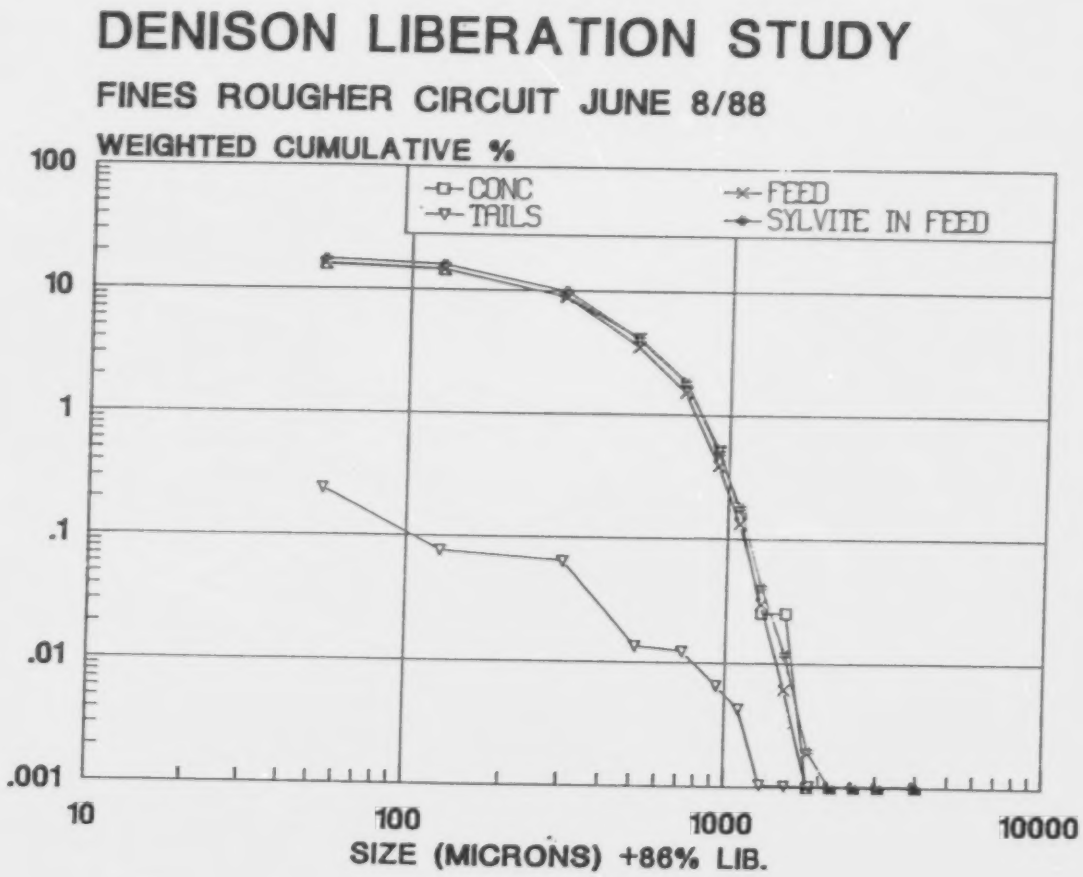



FIGURE 15 Weighted liberation curves for the fines rougher flotation circuit. The weighting factor is the mill balance. The sylvite in the feed is both the liberated and unliberated sylvite.

## 7.0 CONCLUSIONS

The composition of the ore is variable across the sylvinite bed with no obvious systematic variations. The texture of the ore can be best described as gneissic and this results in irregular grain boundaries which may cause problems in achieving a good liberation. The metamorphic grade of the deposit is probably lower greenschist as inferred from the clay mineralogy and the boron minerals.

Salt horses have a Br chemistry similar to the ore and texturally the halite replaced the sylvite. The salt horses are the result of NaCl saturated brines dissolving the sylvite and precipitating halite in channelways in the sylvinite.

In the coarse and regrind rougher flotation circuits much of the coarse (>1000 micron) liberated sylvite reported to the tails. Overall the fines rougher flotation circuit had the best performance, and it had the least amount of material greater than 1000 microns. In both the regrind and the fines circuit there was a slight increase in the amount of sylvite in the less than 60 micron fraction.

## 8.0 RECOMMENDATIONS

To further understand the genesis of salt horses fluid inclusion and isotopic studies should be undertaken. This should give an indication as to the origin of the brine and its composition.

To better determine the metamorphic grade of the deposit, the fluid inclusions should be studied and the clay and boron assemblages further studied. It may be necessary to produce these assemblages experimentally.

The grain size distribution of the crushed ore should be narrower, that is the grain size distribution should be between 100 and 1000 microns. Bench followed by pilot tests should be carried in order to determine the best way to narrow the grain size distribution.

Test should be carried out to improve the flotation of coarse liberated sylvite. The mill personnel have observed that the non-floating coarse sylvite has a dark red colour. No reasons for this coloration were found during very preliminary mineralogical investigations. A more extensive mineralogical studies should be preformed.

If changes are made to the circuits, another image analysis survey would be useful in order to evaluate the changes and find other areas where improvements could be made.

## REFERENCES

**Brindley,G. W. and Brown, G.** (Eds.) 1984: Crystal Structures of Clay Minerals and Their X-ray Identification, Mineralogical Society Monograph No. 5, 495p.

**Burns, P. C.**, 1988: Hexaborates from the Cassidy Lake Formation Sussex, New Brunswick, Unpub. Undergraduate Thesis, Dept. of Geology, University of New Brunswick, 77p.

**Herrmann, A. G.**, 1980: Bromide distribution between halite and NaCl-saturated seawater, Chemical Geology **28**, 171-177.

**Linn, K. O., and Adams, S. S.**, 1961: Barren halite zones in potash deposits Carlsbad, New Mexico, In: Second Symposium on Salt, Jon L. Ran Ed., 1961, The Northern Ohio Geological Society Inc., Cleveland, Ohio, 59-69.

**McIntosh, R. A. and Wardlaw, K. C.**, 1968: Barren halite bodies in the sylvinite mining zone at Esterhazy, Saskatchewan, Can. J. Earth Sci. **5**, 1221-1238.

**Stirling, J. A. R., Roulston, B., and Waugh, D. C. E.**, 1988: Preliminary Results of the Bromine and Partitioning in the Salt Deposits at Sussex, New Brunswick (Abstr.) Atlantic Geoscience Society 1988 Mtg. In: Maritime Sediments and Atlantic Geology, **24**, 213-214.

**Stirling, J. A. R., Kashani, B., and Nance, D.**, 1983: Geochemistry of selected rocks, Vacherie salt dome, Louisiana, La. State Univ. at B.R., Inst. Envir. Studies Topical Report E530-02200-T-8.

**Stoessell, R. K. and Carpenter, A. B.**, 1986: Stoichiometric saturation tests of $NaCl_{1-x}Br_x$ and $KCl_{1-x}Br_x$, Geochim. Cosmochim. Acta **46**, 1465-1474.

**Srodon,Jan and Eberl, D.D.**, 1984: Illites, In: Bailey, S. W. (Ed.), Micas, Mineralogical Society of America Reviews in Mineralogy, **13**, 495-544.

**Walker, T. R., Waugh, B. and Crone, A. J.**, 1978: Diagenesis in first-cycle desert alluvium of Cenozoic age, southwestern United States and northwestern Mexico, Geol. Soc. Amer. Bull. **89**, 19-32.

**Hoffman, S.J., Crosby, K.S., and Irvine J.A.**, 1987: A Lithogeochemical Approach to Stratigraphical Problems of the Millstream Potash Deposit, New Brunswick, Canada, Journal of Geochemical Exploration 28, 103-117.

**Petruk, W.**, 1986: The MP-SEM-IPS Image Analysis System and Its Application ot Mineralogy and Geochemistry, CANMET Mineral Sciences Laboratories Division Report MSL 86-78, 25p.

**Petruk, W., Pinard, R.G., and Finch, J.**, 1986: Relationship between observed mineral liberations in screened fractions and in composite samples. Minerals and Metallurgical Processing 3, 60-62.

**Roulston, B.V. and Waugh, D.C.E.**, 1983: Stratigraphic Comparison of the Mississippian Potash Deposits in New Brunswick, Canada in Sixth Internation Symposium on Salt 1, 115-130.

**Waugh, D.C.E., and Urquhard**, 1983: The Geology of Denison-Potacan's New Brunswick Potash Deposit in Sixth International Symposium on Salt V. 1, 85-98.

# APPENDIX A-1
# SAMPLE CATALOGUE

| NO. | DESCRIPTION | DENISON POTACAN |
|---|---|---|

Note: Due to budget constraints not all samples collected were studied in detail.

| | |
|---|---|
| 5051 | Sample # 1975 Potacan |
| 5052 | Sample # 1976 |
| 5053 | Sample # 1977 |
| 5054 | Sample # 1979 |
| 5055 | Sample # 1974 |
| 5056 | Sample # 1982 |
| 5057 | Sample # 1983 |
| 5058 | Sample # 1984 |
| 5059 | Sample # 1985 |
| 5060 | Sample # 1986 |
| 5061 | Sample # 1987 |
| 5062 | Sample # 1988 |
| 5063 | Sample # 1989 |
| 5064 | Sample # 1990 (AIA chord measurements) |
| 5065 | Sample # 1991 (AIA chord maesurements) |
| 5066 | Sample # 1992 |
| 5067 | Sample # 1993 |
| 5068 | Sample # 1994 |
| 5069 | Mineralized ore #2 |
| 5070 | Barren ore #2 1980 |
| 5071 | Barren ore # 1 |
| 5105 | Gray clay from E zone 2901 |
| 5106 | Red brown clay from DH #87-10-E zone |
| 5107 | Barren zone sylvinite bed Potacan 2903 |
| 5108 | Barren zone middle (same as 2903) Potacan 2904 |
| 5109 | Barren zone (bottom as 2903) Potacan 2905 |
| 5110 | Barren zone bottom (same as 2906) Potacan 2908 |
| 5111 | Barren zone middle as 2906 Potacan 2907 |
| 5116 | Denison Foliated ore 2967: |
| | A: perpenticular to foliation and lineation |
| | B: parallel to lineation and perpendicular to foliation |

| NO. | DESCRIPTION | DENISON POTACAN |
|---|---|---|
| 5117 | Denison anhydrite 2965 | |
| 5118 | Large dia. core | |
| 5119 | Borates Denison 2968 | |
| 5120 | Borates Denison 2969 | |
| 5121 | Borates Denison 2970 | |
| 5122 | Borates Denison 2971 | |

Samples 5189 to 5191 were analyzed by AIA and the results were used as a demo.

| | |
|---|---|
| 5189 | Coarse rougher concentrate |
| 5190 | Coarse rougher tails |
| 5191 | Coarse rougher feed |
| 5192 | Mill circuit clays. Thickeners U/F Aug. 27, 1987 |
| 5193 | Grey-green clay sample taken from a halite sample. The sample was taken at the E-zone - Upper halite contact in the 11-280 slope of the Denison Potacan Potash Company's mine. |
| 5194 | Grey-green clay sample taken from a halite sample. The sample was taken one meter below the E-zone Upper halite contact in the 11-280 stope of the Denison Potacan Company's mine. |
| 5195 | Orange clay sample taken from a halite sample. The sample was taken at the E-zone - Upper halite contact in the 11-280 stope of the Denison Potacan Potash Company's mine. |

Samples 5196 to 5198 were collected to evaluate recovery, however they were too agglomerated to be analysis by AIA

| | |
|---|---|
| 5196 | Denison - poor recovery - regrind feed May 17, 1988 |
| 5197 | Denison - poor recovery - regrind conc. May 17, 1988 |
| 5198 | Denison - poor recovery - regrind tail May 17, 1988 |
| 5199A | Crystallization product May 18, 1988 |
| 5199 | Coarse rougher feed June 8/88 |
| 5200 | Denison coarse reagentizing drum discharge June 8/88 |
| 5201 | Coarse rougher concentrate June 8/88 |

DENISON POTACAN

| NO. | DESCRIPTION |
|---|---|
| 5202 | Coarse rougher tailings June 8/88 |
| 5203 | Fines rougher feed June 8/88 |
| 5204 | Fines rougher concentrate June 8/88 |
| 5205 | Fines Rougher tailings June 8/88 |
| 5206 | Regrind rougher feed June 8/88 |
| 5207 | Regrind rougher concentrate June 8/88 |
| 5208 | Regrind rougher tailings June 8/88 |
| 5209 | Slimes flotation feed June 8/88 |
| 5210 | Slimes flotation concentrate June 8/88 |
| 5211 | Slimes flotation tails June 8/88 |

# APPENDIX A-2

# BR CONTENT OF HALITE AND SYLVITE

PCA HALITE 5023

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| HALITE | 39.31 | .00 | 59.27 | 20 | 98.58 |
| | 39.91 | .08 | 61.31 | 90 | 101.31 |
| | 39.73 | .04 | 60.76 | 192 | 100.55 |
| | 40.08 | .06 | 61.86 | 42 | 102.00 |
| | 39.62 | .06 | 60.87 | 0 | 100.55 |
| | 40.59 | .06 | 61.36 | 0 | 102.01 |
| | 39.75 | .04 | 60.96 | 0 | 100.75 |
| | 40.25 | .02 | 62.57 | 153 | 102.86 |
| | 40.92 | .08 | 63.23 | 176 | 104.25 |
| | 40.37 | .00 | 61.31 | 0 | 101.68 |
| | 39.81 | .08 | 61.61 | 26 | 101.50 |
| | 40.17 | .02 | 62.01 | 0 | 102.20 |
| | 40.36 | .08 | 62.12 | 54 | 102.57 |
| | 40.02 | .03 | 65.93 | 16 | 105.98 |
| | 39.53 | .07 | 61.46 | 0 | 101.06 |
| | 38.88 | .03 | 60.06 | 54 | 98.98 |
| | 39.26 | .07 | 61.12 | 38 | 100.45 |
| | 39.34 | .04 | 60.44 | 0 | 99.82 |
| | 39.06 | .05 | 61.72 | 48 | 100.83 |
| | 39.53 | .04 | 62.46 | 0 | 102.03 |

PCA ORE 5034

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .05 | 52.89 | 44.87 | 473 | 97.86 |
| | .03 | 53.39 | 47.82 | 1221 | 101.36 |
| | .14 | 52.98 | 46.97 | 1052 | 100.20 |
| | .01 | 53.63 | 45.85 | 500 | 99.54 |
| | .93 | 52.96 | 47.84 | 985 | 101.83 |
| | .05 | 54.13 | 47.39 | 3635 | 101.93 |
| | .04 | 53.49 | 44.39 | 2439 | 98.16 |
| | .02 | 54.52 | 46.07 | 3848 | 100.99 |
| | .14 | 53.51 | 47.02 | 3353 | 101.01 |
| | .05 | 54.83 | 46.76 | 535 | 101.69 |
| | .02 | 53.65 | 44.83 | 420 | 98.54 |
| | .23 | 53.74 | 45.58 | 3336 | 99.88 |
| | .08 | 53.90 | 45.87 | 2870 | 100.14 |
| | .09 | 53.76 | 45.58 | 3167 | 99.75 |
| | .04 | 53.53 | 45.20 | 2686 | 99.04 |
| | .07 | 52.95 | 44.93 | 4000 | 98.35 |
| | .11 | 53.55 | 44.98 | 3164 | 98.96 |
| | .10 | 53.44 | 45.53 | 2338 | 99.30 |
| | .04 | 54.46 | 46.95 | 2743 | 101.72 |
| | .09 | 54.04 | 46.89 | 250 | 101.05 |
| HALITE | 39.02 | .03 | 59.92 | 609 | 99.03 |
| | 39.22 | .01 | 58.68 | 166 | 97.93 |
| | 39.03 | .08 | 59.29 | 297 | 98.43 |
| | 38.76 | .11 | 58.97 | 609 | 97.90 |
| | 38.85 | .04 | 58.29 | 235 | 97.20 |
| | 38.87 | .20 | 58.26 | 204 | 97.35 |
| | 38.90 | .12 | 59.52 | 125 | 98.55 |
| | 38.55 | .23 | 57.27 | 590 | 96.11 |
| | 38.84 | .09 | 60.03 | 508 | 99.01 |
| | 39.17 | .29 | 60.68 | 302 | 100.17 |
| | 39.01 | .10 | 58.22 | 499 | 97.38 |
| | 39.13 | .00 | 58.54 | 410 | 97.71 |
| | 38.87 | .11 | 60.03 | 274 | 99.04 |
| | 38.00 | .00 | 58.03 | 300 | 96.06 |
| | 39.25 | .10 | 59.92 | 422 | 99.31 |
| | 40.17 | .03 | 57.95 | 123 | 98.16 |
| | 39.00 | .02 | 60.33 | 486 | 99.40 |
| | 39.72 | .10 | 59.57 | 417 | 99.43 |
| | 38.46 | .08 | 59.57 | 143 | 98.12 |
| | 39.96 | .09 | 58.45 | 440 | 98.54 |

PCA SALT HORSE 5042A

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .12 | 56.74 | 46.67 | 1993 | 103.73 |
| | .15 | 55.08 | 45.04 | 1934 | 100.46 |
| | .27 | 54.57 | 46.06 | 1103 | 101.01 |
| | .33 | 55.83 | 45.74 | 854 | 101.99 |
| | .12 | 55.19 | 46.60 | 935 | 102.00 |
| | .74 | 55.12 | 46.86 | 991 | 102.82 |
| | .23 | 54.62 | 46.32 | 1226 | 101.29 |
| | .06 | 55.03 | 45.36 | 2477 | 100.70 |
| | .19 | 54.96 | 46.43 | 2293 | 101.81 |
| | 1.31 | 54.64 | 46.33 | 1577 | 102.44 |
| | 1.11 | 55.08 | 46.08 | 2817 | 102.55 |
| | .51 | 55.12 | 46.39 | 1095 | 102.13 |
| | .25 | 56.52 | 47.22 | 1374 | 104.13 |
| | .21 | 57.19 | 46.56 | 3934 | 104.35 |
| | .17 | 57.14 | 46.91 | 2214 | 104.44 |
| | .07 | 56.25 | 45.57 | 2188 | 102.11 |
| | 1.61 | 54.37 | 45.78 | 1606 | 101.92 |
| | .34 | 55.44 | 46.09 | 1210 | 101.99 |
| | .26 | 56.20 | 46.98 | 1973 | 103.64 |
| | .18 | 56.83 | 46.32 | 2151 | 103.55 |
| HALITE | 40.46 | .04 | 59.06 | 0 | 99.56 |
| | 41.61 | .10 | 60.35 | 164 | 102.08 |
| | 40.82 | .03 | 62.06 | 315 | 102.94 |
| | 40.50 | .09 | 59.85 | 31 | 100.44 |
| | 40.83 | .03 | 60.73 | 376 | 101.68 |
| | 40.24 | .04 | 61.10 | 106 | 101.39 |
| | 39.99 | .08 | 60.18 | 260 | 100.28 |
| | 40.05 | .06 | 60.11 | 56 | 100.23 |
| | 41.34 | .17 | 60.62 | 189 | 102.15 |
| | 40.74 | .06 | 59.57 | 145 | 100.38 |
| | 40.51 | .12 | 60.36 | 448 | 101.03 |
| | 41.56 | .15 | 60.09 | 384 | 101.84 |
| | 41.44 | .11 | 61.86 | 0 | 103.41 |
| | 40.78 | .07 | 59.58 | 211 | 100.45 |
| | 40.25 | .06 | 60.90 | 188 | 101.23 |
| | 40.21 | .09 | 60.66 | 347 | 100.99 |
| | 39.42 | .16 | 61.08 | 296 | 100.69 |
| | 40.12 | .07 | 59.89 | 154 | 100.10 |
| | 40.39 | .09 | 58.35 | 101 | 98.84 |
| | 39.87 | .04 | 59.13 | 267 | 99.07 |

POTACAN ORE 5064

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .13 | 50.34 | 46.36 | 2343 | 97.06 |
| | .11 | 50.48 | 46.83 | 2098 | 97.63 |
| | .17 | 50.39 | 46.80 | 2326 | 97.59 |
| | .15 | 50.41 | 47.19 | 2377 | 97.99 |
| | .22 | 50.49 | 47.49 | 2267 | 98.42 |
| | .22 | 50.06 | 46.61 | 2114 | 97.10 |
| | .16 | 49.65 | 47.56 | 2103 | 97.58 |
| | .17 | 51.28 | 47.83 | 2527 | 99.53 |
| | .12 | 50.79 | 47.60 | 2210 | 98.73 |
| | .24 | 51.08 | 46.80 | 1607 | 98.28 |
| | .14 | 51.28 | 46.92 | 2275 | 98.57 |
| | .15 | 51.53 | 47.35 | 1845 | 99.21 |
| | .13 | 51.72 | 46.39 | 2036 | 98.44 |
| | .18 | 51.00 | 47.31 | 2024 | 98.69 |
| | .14 | 51.31 | 47.53 | 2265 | 99.21 |
| | .21 | 50.90 | 47.18 | 1996 | 98.49 |
| | .32 | 50.75 | 47.80 | 2137 | 99.08 |
| | .17 | 50.58 | 47.08 | 1199 | 97.95 |
| | .19 | 50.78 | 46.95 | 2389 | 98.16 |
| | .18 | 51.08 | 48.22 | 1426 | 99.62 |
| HALITE | 40.51 | .02 | 61.29 | 73 | 101.83 |
| | 41.73 | .05 | 61.47 | 224 | 103.27 |
| | 40.94 | .00 | 60.78 | 21 | 101.72 |
| | 41.42 | .08 | 60.82 | 52 | 102.33 |
| | 40.97 | .08 | 61.41 | 66 | 102.47 |
| | 40.75 | .08 | 61.01 | 341 | 101.87 |
| | 40.09 | .02 | 60.88 | 229 | 101.01 |
| | 40.35 | .02 | 61.84 | 265 | 102.24 |
| | 41.04 | .03 | 61.15 | 62 | 102.23 |
| | 40.68 | .03 | 60.17 | 181 | 100.90 |
| | 40.18 | .01 | 61.20 | 212 | 101.41 |
| | 40.14 | .06 | 60.88 | 257 | 101.11 |
| | 41.05 | .01 | 60.93 | 0 | 101.99 |
| | 40.31 | .11 | 60.85 | 422 | 101.31 |
| | 40.08 | .03 | 60.79 | 73 | 100.91 |
| | 40.52 | .04 | 60.80 | 144 | 101.37 |
| | 40.32 | .10 | 61.37 | 270 | 101.82 |
| | 40.01 | .05 | 60.52 | 129 | 100.59 |
| | 40.21 | .10 | 60.08 | 152 | 100.41 |
| | 40.97 | .07 | 61.04 | 187 | 102.10 |

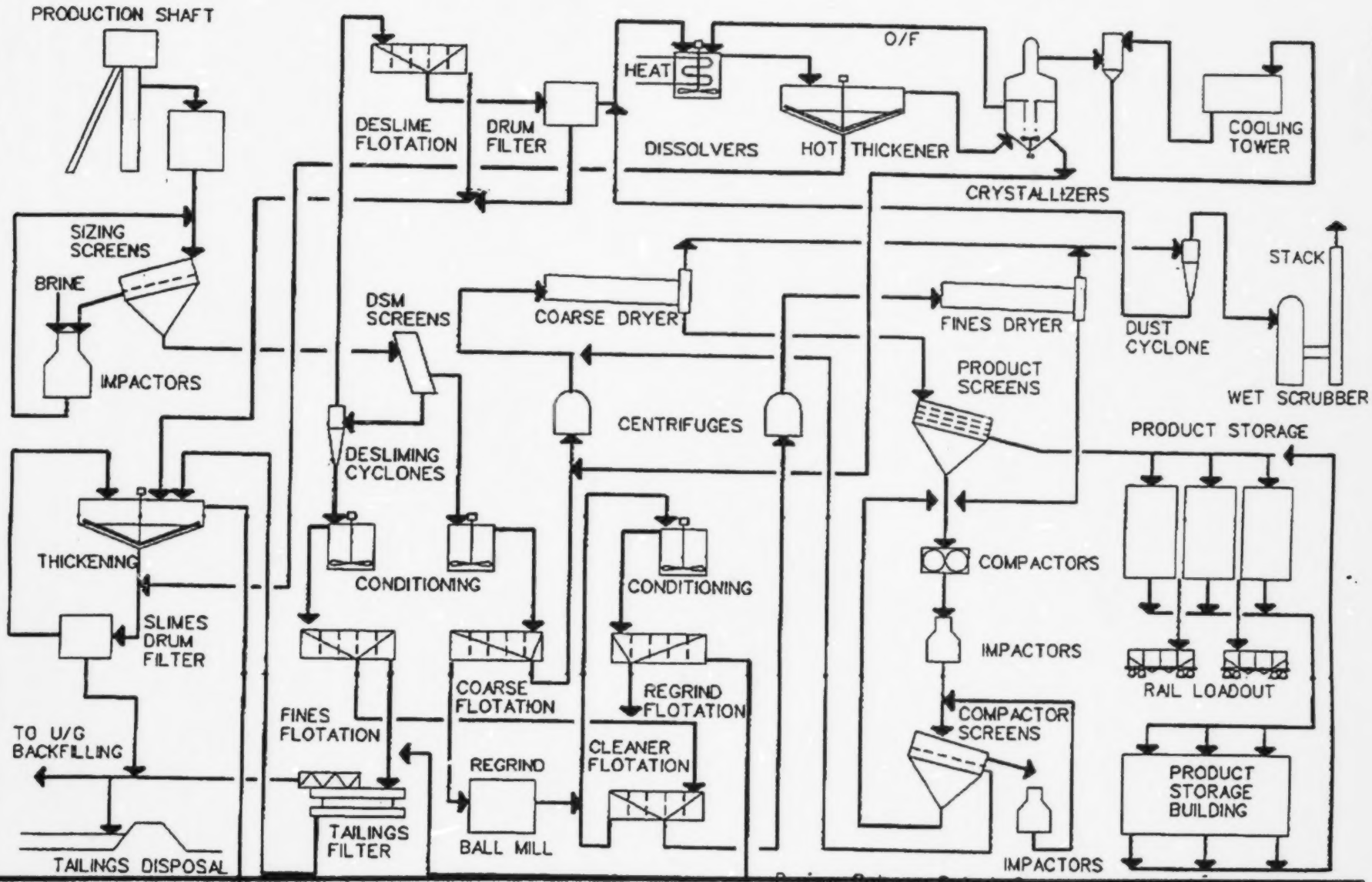
POTACAN ORE 5065

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .30 | 51.44 | 44.21 | 2689 | 96.22 |
| | .17 | 51.75 | 44.04 | 1954 | 96.16 |
| | 1.21 | 50.27 | 44.68 | 509 | 96.21 |
| | .23 | 52.02 | 44.48 | 983 | 96.83 |
| | .42 | 50.79 | 44.67 | 1083 | 95.99 |
| | .53 | 51.63 | 45.87 | 3515 | 98.38 |
| | .23 | 51.83 | 44.05 | 3552 | 96.47 |
| | .19 | 51.62 | 44.70 | 1293 | 96.64 |
| | .86 | 49.79 | 44.22 | 1195 | 94.99 |
| | .40 | 50.06 | 44.07 | 2363 | 94.77 |
| HALITE | 39.35 | .08 | 57.88 | 105 | 97.32 |
| | 40.23 | .08 | 57.04 | 197 | 97.37 |
| | 39.66 | .05 | 56.93 | 171 | 96.66 |
| | 39.41 | .11 | 57.40 | 21 | 96.92 |
| | 39.41 | .08 | 57.24 | 42 | 96.73 |
| | 39.99 | .04 | 57.53 | 0 | 97.56 |
| | 39.92 | .09 | 57.46 | 129 | 97.48 |
| | 38.68 | .16 | 55.84 | 302 | 94.71 |
| | 39.66 | .04 | 57.51 | 160 | 97.23 |
| | 40.00 | .04 | 57.93 | 203 | 97.99 |

POTACAN HORSE 5070

| | NA WT% | K WT% | CL WT% | BR PPM | TOTAL |
|---|---|---|---|---|---|
| SYLVITE | .18 | 50.89 | 45.27 | 2096 | 96.55 |
| | .30 | 50.89 | 47.22 | 2235 | 98.63 |
| | .28 | 50.76 | 47.22 | 1024 | 98.36 |
| | .36 | 50.66 | 46.55 | 1224 | 97.69 |
| | .28 | 51.06 | 46.23 | 2114 | 97.78 |
| | .70 | 51.13 | 48.01 | 2102 | 100.05 |
| | .17 | 51.09 | 47.63 | 1862 | 99.08 |
| | .31 | 51.16 | 47.12 | 1225 | 98.71 |
| | .30 | 51.72 | 47.10 | 1096 | 99.23 |
| | .79 | 51.42 | 48.14 | 1333 | 100.48 |
| HALITE | 40.15 | .07 | 61.16 | 156 | 101.40 |
| | 39.80 | .01 | 61.63 | 159 | 101.46 |
| | 40.47 | .02 | 61.18 | 312 | 101.70 |
| | 39.74 | .06 | 62.07 | 64 | 101.88 |
| | 40.02 | .09 | 61.48 | 147 | 101.60 |
| | 39.78 | .07 | 61.48 | 163 | 101.35 |
| | 40.00 | .08 | 62.10 | 48 | 102.18 |
| | 39.12 | .02 | 60.95 | 244 | 100.11 |
| | 40.02 | .08 | 61.83 | 321 | 101.96 |
| | 39.82 | .05 | 62.20 | 89 | 102.08 |
| | 40.07 | .02 | 62.33 | 87 | 102.43 |
| | 39.73 | .06 | 63.27 | 56 | 103.07 |
| | 40.03 | .04 | 61.93 | 106 | 102.01 |
| | 39.92 | .07 | 60.83 | 64 | 100.83 |
| | 39.69 | .04 | 61.86 | 202 | 101.61 |
| | 39.63 | .01 | 62.01 | 68 | 101.66 |
| | 39.25 | .04 | 62.93 | 113 | 102.23 |
| | 39.75 | .06 | 62.12 | 54 | 101.94 |
| | 39.77 | .01 | 61.93 | 118 | 101.72 |
| | 39.65 | .05 | 61.76 | 194 | 101.48 |

# APPENDIX A-3
# DENISON POTACAN CONCENTRATOR FLOWSHEET




Denison Potacan Potash Company

# CLOVER HILL POTASH PROJECT

BENEFICIATION FLOW DIAGRAM

# APPENDIX A-4
# CHEMICAL COMPOSITION OF MILL SAMPLES
# COLLECTED JUNE 1988

TABLE CHEMICAL ANALYSIS OF DENISON POTACAN MILL SAMPLES COLLECTED JUNE 8, 1988

| DESCRIPTION | COARSE ROUGH FEED | COARSE REAG D DIS | COARSE ROUGH CONC | COARSE ROUGH TAILS | FINE ROUGH FEED | FINE ROUGH CONC | FINE ROUGH TAIL | REGR ROUGH FEED | REGR ROUGH CONC | REGR ROUGH TAIL | SLIMES FLOT FEED | SLIMES FLOT CONC | SLIMES FLOT TAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | 5199 | 5200 | 5201 | 5202 | 5203 | 5204 | 5205 | 5206 | 5207 | 5208 | 5209 | 5210 | 5211 |
| WT% | | | | | | | | | | | | | |
| K | 21.10 | 19.36 | 49.32 | 7.76 | 21.81 | 48.41 | 1.27 | 8.83 | 41.58 | 5.40 | 26.35 | 44.78 | 13.56 |
| CA | .13 | nd | .04 | nd | nd | .10 | .05 | nd | .09 | .19 | .22 | .10 | .35 |
| NA | 22.48 | 23.70 | 2.87 | 31.07 | 22.07 | 4.29 | 36.78 | 31.70 | 7.87 | 34.06 | 18.57 | 6.44 | 29.20 |
| CL | 53.20 | 53.50 | 45.94 | 56.05 | 53.27 | 45.26 | 59.23 | 57.77 | 49.09 | 57.95 | 52.24 | 50.51 | 55.06 |
| SO4 | | | | | | | | | | | | | |
| INSOLUBLES | | | | | | | | | | | | | |
| TOTAL | 96.91 | 96.56 | 98.17 | 94.88 | 97.14 | 98.05 | 97.32 | 98.30 | 98.62 | 97.60 | 97.37 | 101.83 | 98.16 |
| NORM | | | | | | | | | | | | | |
| SYLVITE K | 40.23 | 36.91 | 94.04 | 14.80 | 41.58 | 92.30 | 2.42 | 16.84 | 79.27 | 10.30 | 50.23 | 85.37 | 25.85 |
| HALITE NA | 57.15 | 60.25 | 7.30 | 78.98 | 56.09 | 10.89 | 93.48 | 80.58 | 19.99 | 86.58 | 47.19 | 16.37 | 74.21 |
| ANAL. CL | 53.20 | 53.50 | 45.94 | 56.05 | 53.27 | 45.26 | 59.23 | 57.77 | 49.09 | 57.95 | 52.24 | 50.51 | 55.06 |
| CAL. CL | 53.80 | 54.10 | 49.14 | 54.95 | 53.80 | 50.50 | 57.86 | 56.89 | 49.82 | 57.42 | 52.51 | 50.53 | 57.31 |
| ANHYDRITE | .44 | .00 | .14 | .00 | .00 | .34 | .15 | .00 | .31 | .65 | .75 | .34 | 1.19 |
| CAL SO4 | .31 | .00 | .10 | .00 | .00 | .24 | .11 | .00 | .22 | .46 | .53 | .24 | .84 |
| INSOLUBLES | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| NORM TOTAL | 97.82 | 97.16 | 101.47 | 93.78 | 97.67 | 103.53 | 96.06 | 97.42 | 99.57 | 97.52 | 98.17 | 102.08 | 101.26 |

RESEARCH AND PRODUCTIVITY COUNCIL

# APPENDIX A-5
# SIEVE ANALYSIS, MODAL MINERALOGY AND LIBERATION DATA OF SAMPLE COLLECTED, JUNE 1988

TABLE DENISON POTACAN NORMALIZED SIEVE ANALYSES OF MILL SAMPLES JUNE 8/88

| WT G SAMPLE | COARSE ROUGH FEED 5199 | COARSE DRUM DIS 5200 | COARSE ROUGH CONC 5201 | COARSE ROUGH TAIL 5202 | FINE ROUGH FEED 5203 | FINE ROUGH CONC 5204 | RINE ROUGH TAIL 5205 | REGR ROUGH FEED 5206 | REGR ROUGH CONC 5207 | REGR ROUGH TAILS 5208 |
|---|---|---|---|---|---|---|---|---|---|---|
| -37 NM | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| +37 | 3.48 | 2.86 | 5.50 | 2.85 | 7.79 | 8.57 | 10.46 | 8.24 | 7.64 | 12.02 |
| +75 | 6.19 | 5.29 | 9.99 | 3.67 | 31.58 | 33.29 | 35.11 | 19.16 | 18.21 | 22.41 |
| +212 | 13.62 | 13.11 | 20.76 | 9.52 | 32.40 | 30.77 | 28.84 | 23.54 | 23.00 | 23.05 |
| +425 | 13.07 | 12.97 | 19.49 | 9.63 | 14.94 | 14.94 | 13.80 | 14.56 | 13.56 | 14.28 |
| +600 | 16.82 | 16.46 | 23.01 | 14.44 | 9.44 | 9.01 | 8.56 | 15.36 | 15.98 | 14.47 |
| +850 | 10.01 | 10.02 | 10.07 | 10.19 | 2.39 | 2.26 | 2.02 | 7.71 | 9.40 | 6.09 |
| +1.00MM | 8.73 | 9.36 | 6.33 | 11.55 | 1.04 | .86 | .83 | 5.77 | 7.06 | 4.13 |
| +1.18 | 8.67 | 8.74 | 3.33 | 10.12 | .30 | .22 | .27 | 3.61 | 3.28 | 2.27 |
| +1.40 | 7.20 | 8.44 | 1.29 | 10.94 | .08 | .07 | .07 | 1.73 | 1.66 | .94 |
| +1.70 | 4.40 | 4.88 | .21 | 7.19 | .01 | .02 | .01 | .23 | .20 | .25 |
| +2.00 | 4.54 | 4.57 | .03 | 6.05 | .02 | .01 | .04 | .08 | .02 | .08 |
| +2.36 | 1.96 | 2.34 | .00 | 2.44 | .00 | .00 | .00 | .01 | .00 | .00 |
| +2.80 | .96 | .69 | .00 | 1.14 | .00 | .00 | .00 | .00 | .00 | .00 |
| +3.35 | .36 | .26 | .00 | .30 | .00 | .00 | .00 | .00 | .00 | .00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

COARSE ROUGHER FEED RPC #5199

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .54 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 27.50 | 45.00 | 27.50 | 37.93 | 62.07 | 37.93 | 100.00 | 3.48 | 2.16 | 1.17 | |
| +75 | 126 | 32.50 | 35.10 | 32.40 | 48.08 | 51.92 | 47.93 | 99.69 | 6.19 | 3.21 | 1.74 | |
| +212 | 300 | 35.80 | 28.50 | 35.70 | 55.68 | 44.32 | 55.52 | 99.72 | 13.62 | 6.04 | 3.26 | |
| +425 | 505 | 36.50 | 27.40 | 36.10 | 57.12 | 42.88 | 56.49 | 98.90 | 13.07 | 5.60 | 3.03 | |
| +600 | 714 | 40.50 | 19.00 | 40.50 | 68.07 | 31.93 | 68.07 | 100.00 | 16.82 | 5.37 | 2.90 | |
| +850 | 922 | 40.40 | 19.70 | 39.90 | 67.22 | 32.78 | 66.39 | 98.76 | 10.01 | 3.28 | 1.77 | |
| +1.00MM | 1086 | 41.90 | 16.10 | 41.90 | 72.24 | 27.76 | 72.24 | 100.00 | 8.73 | 2.42 | 1.31 | |
| +1.18 | 1285 | 43.80 | 12.60 | 43.70 | 77.66 | 22.34 | 77.48 | 99.77 | 8.67 | 1.94 | 1.05 | |
| +1.40 | 1543 | 40.70 | 18.60 | 40.70 | 68.63 | 31.37 | 68.63 | 100.00 | 7.20 | 2.26 | 1.22 | |
| +1.70 | 1844 | 42.70 | 14.70 | 42.60 | 74.39 | 25.61 | 74.22 | 99.77 | 4.40 | 1.13 | .61 | |
| +2.00 | 2173 | 42.10 | 16.00 | 41.90 | 72.46 | 27.54 | 72.12 | 99.52 | 4.54 | 1.25 | .68 | |
| +2.36 | 2571 | 36.90 | 26.90 | 36.20 | 57.84 | 42.16 | 56.74 | 98.10 | 1.96 | .83 | .45 | |
| +2.80 | 3063 | 42.00 | 16.70 | 41.30 | 71.55 | 28.45 | 70.36 | 98.33 | .96 | .27 | .15 | |
| +3.35 | 4000 | 49.60 | 9.67 | 40.70 | 83.68 | 16.32 | 68.67 | 82.06 | .36 | .06 | .03 | |
| | | | | | | | | | 100.01 | 35.82 | 19.34 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

COARSE REAGENTIZING DRUM DISCHARGE #5200

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .53 AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 32.70 | 34.80 | 32.50 | 48.44 | 51.56 | 48.15 | 99.39 | 2.86 | 1.47 | .78 | |
| +75 | 126 | 35.30 | 29.40 | 35.30 | 54.56 | 45.44 | 54.56 | 100.00 | 5.29 | 2.40 | 1.27 | |
| +212 | 300 | 36.10 | 27.90 | 36.10 | 56.41 | 43.59 | 56.41 | 100.00 | 13.11 | 5.72 | 3.03 | |
| +425 | 505 | 38.40 | 23.20 | 38.40 | 62.34 | 37.66 | 62.34 | 100.00 | 12.97 | 4.88 | 2.59 | |
| +600 | 714 | 39.40 | 21.30 | 39.30 | 64.91 | 35.09 | 64.74 | 99.75 | 16.46 | 5.78 | 3.06 | |
| +850 | 922 | 43.00 | 14.00 | 43.00 | 75.44 | 24.56 | 75.44 | 100.00 | 10.02 | 2.46 | 1.30 | |
| +1.00MM | 1086 | 39.30 | 21.60 | 39.10 | 64.53 | 35.47 | 64.20 | 99.49 | 9.36 | 3.32 | 1.76 | |
| +1.18 | 1285 | 42.60 | 14.80 | 42.60 | 74.22 | 25.78 | 74.22 | 100.00 | 8.74 | 2.25 | 1.19 | |
| +1.40 | 1543 | 41.60 | 17.10 | 41.20 | 70.87 | 29.13 | 70.19 | 99.04 | 8.44 | 2.46 | 1.30 | |
| +1.70 | 1844 | 42.40 | 15.30 | 42.30 | 73.48 | 26.52 | 73.31 | 99.76 | 4.88 | 1.29 | .69 | |
| +2.00 | 2173 | 41.60 | 16.90 | 41.50 | 71.11 | 28.89 | 70.94 | 99.76 | 4.57 | 1.32 | .70 | |
| +2.36 | 2571 | 40.70 | 21.20 | 38.10 | 65.75 | 34.25 | 61.55 | 93.61 | 2.34 | .80 | .42 | |
| +2.80 | 3063 | 43.20 | 14.70 | 42.00 | 74.61 | 25.39 | 72.54 | 97.22 | .69 | .18 | .09 | |
| +3.35 | 4000 | 40.70 | 21.50 | 37.70 | 65.43 | 34.57 | 60.61 | 92.63 | .26 | .09 | .05 | |
| | | | | | | | | | 99.99 | 34.43 | 18.25 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

COARSE ROUGHER CONCENTRATE #5201

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE % | .17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +38 NM | 53 | 11.70 | 76.70 | 11.60 | 13.24 | 86.76 | 13.12 | 99.15 | 5.50 | 4.77 | .81 | |
| +75 | 126 | 9.22 | 81.70 | 9.07 | 10.14 | 89.86 | 9.98 | 98.37 | 9.99 | 8.98 | 1.53 | |
| +212 | 300 | 7.96 | 84.20 | 7.88 | 8.64 | 91.36 | 8.55 | 98.99 | 20.76 | 18.97 | 3.22 | |
| +425 | 505 | 9.30 | 81.90 | 8.83 | 10.20 | 89.80 | 9.68 | 94.95 | 19.49 | 17.50 | 2.98 | |
| +600 | 714 | 7.07 | 86.00 | 6.90 | 7.60 | 92.40 | 7.41 | 97.60 | 23.01 | 21.26 | 3.61 | |
| +850 | 922 | 6.63 | 87.00 | 6.37 | 7.08 | 92.92 | 6.80 | 96.08 | 10.07 | 9.36 | 1.59 | |
| +1.00MM | 1086 | 5.78 | 88.70 | 5.47 | 6.12 | 93.88 | 5.79 | 94.64 | 6.33 | 5.94 | 1.01 | |
| +1.18 | 1285 | 2.80 | 94.70 | 2.50 | 2.87 | 97.13 | 2.56 | 89.29 | 3.33 | 3.23 | .55 | |
| +1.40 | 1543 | 4.23 | 92.00 | 3.74 | 4.40 | 95.60 | 3.89 | 88.42 | 1.29 | 1.23 | .21 | |
| +1.70 | 1844 | 7.67 | 85.10 | 7.19 | 8.27 | 91.73 | 7.75 | 93.74 | .21 | .19 | .03 | |
| +2.00 | 2173 | 31.98 | 50.83 | 16.86 | 38.62 | 61.38 | 20.36 | 52.72 | .03 | .02 | .00 | |
| +2.36 | 2571 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | 31.98 | | | | | 100.01 | 91.46 | 15.55 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

COARSE ROUGHER TAILINGS #5202

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .37 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 37.20 | 26.10 | 36.70 | 58.77 | 41.23 | 57.98 | 98.66 | 2.85 | 1.18 | .43 | |
| +75 | 126 | 49.10 | 1.77 | 49.10 | 96.52 | 3.48 | 96.52 | 100.00 | 3.67 | .13 | .05 | |
| +212 | 300 | 49.70 | .59 | 49.70 | 98.83 | 1.17 | 98.83 | 100.00 | 9.52 | .11 | .04 | |
| +425 | 505 | 49.70 | .68 | 49.70 | 98.64 | 1.36 | 98.64 | 100.00 | 9.63 | .13 | .05 | |
| +600 | 714 | 48.60 | 2.79 | 48.60 | 94.57 | 5.43 | 94.57 | 100.00 | 14.44 | .78 | .29 | |
| +850 | 922 | 46.60 | 6.94 | 46.50 | 87.04 | 12.96 | 86.85 | 99.79 | 10.19 | 1.32 | .49 | |
| +1.00MM | 1086 | 44.20 | 11.90 | 43.90 | 78.79 | 21.21 | 78.25 | 99.32 | 11.55 | 2.45 | .91 | |
| +1.18 | 1285 | 43.80 | 12.50 | 43.70 | 77.80 | 22.20 | 77.62 | 99.77 | 10.12 | 2.25 | .83 | |
| +1.40 | 1543 | 43.40 | 14.90 | 41.70 | 74.44 | 25.56 | 71.53 | 96.08 | 10.94 | 2.80 | 1.03 | |
| +1.70 | 1844 | 43.30 | 17.70 | 39.10 | 70.98 | 29.02 | 64.10 | 90.30 | 7.19 | 2.09 | .77 | |
| +2.00 | 2173 | 42.90 | 17.30 | 39.80 | 71.26 | 28.74 | 66.11 | 92.77 | 6.05 | 1.74 | .64 | |
| +2.36 | 2571 | 40.10 | 20.30 | 39.60 | 66.39 | 33.61 | 65.56 | 98.75 | 2.44 | .82 | .30 | |
| +2.80 | 3063 | 40.90 | 26.20 | 32.90 | 60.95 | 39.05 | 49.03 | 80.44 | 1.14 | .45 | .16 | |
| +3.35 | 4000 | 39.30 | 26.00 | 34.70 | 60.18 | 39.82 | 53.14 | 88.30 | .30 | .12 | .04 | |
| | | | | | | | | | 100.03 | 16.35 | 6.05 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

FINES ROUGHER FEED #5203

| SYLVITE AREA % FRACTIO | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .41 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +38 NM | 53 | 34.60 | 30.80 | 34.50 | 52.91 | 47.09 | 52.75 | 99.71 | 7.79 | 3.67 | 1.50 | |
| +75 | 126 | 34.80 | 30.50 | 34.70 | 53.29 | 46.71 | 53.14 | 99.71 | 31.58 | 14.75 | 6.05 | |
| +212 | 300 | 35.80 | 28.40 | 35.80 | 55.76 | 44.24 | 55.76 | 100.00 | 32.40 | 14.33 | 5.88 | |
| +425 | 505 | 38.40 | 23.30 | 38.30 | 62.24 | 37.76 | 62.07 | 99.74 | 14.94 | 5.64 | 2.31 | |
| +600 | 714 | 39.40 | 21.30 | 39.30 | 64.91 | 35.09 | 64.74 | 99.75 | 9.44 | 3.31 | 1.36 | |
| +850 | 922 | 40.60 | 19.30 | 40.20 | 67.78 | 32.22 | 67.11 | 99.01 | 2.39 | .77 | .32 | |
| +1.00MM | 1086 | 40.20 | 19.60 | 40.20 | 67.22 | 32.78 | 67.22 | 100.00 | 1.04 | .34 | .14 | |
| +1.18 | 1285 | 45.90 | 12.90 | 41.20 | 78.06 | 21.94 | 70.07 | 89.76 | .30 | .07 | .03 | |
| +1.40 | 1543 | 41.90 | 18.80 | 39.30 | 69.03 | 30.97 | 64.74 | 93.79 | .08 | .02 | .01 | |
| +1.70 | 1844 | 34.50 | 31.00 | 34.50 | 52.67 | 47.33 | 52.67 | 100.00 | .01 | .00 | .00 | |
| +2.00 | 2173 | 45.80 | 8.49 | 45.80 | 84.36 | 15.64 | 84.36 | 100.00 | .02 | .00 | .00 | |
| +2.36 | 2571 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | | | | | | 99.99 | 42.92 | 17.60 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

FINES ROUGHER CONCENTRATE #5204

| SYLVITE AREA % FRACTIO | PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | MILL WT SYLVITE | .19 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 15.90 | 68.20 | 15.90 | 18.91 | 81.09 | 18.91 | 100.00 | 8.57 | 6.95 | 1.32 | |
| +75 | 126 | 9.64 | 80.90 | 9.46 | 10.65 | 89.35 | 10.45 | 98.13 | 33.29 | 29.75 | 5.65 | |
| +212 | 300 | 10.20 | 79.70 | 10.10 | 11.35 | 88.65 | 11.23 | 99.02 | 30.77 | 27.28 | 5.18 | |
| +425 | 505 | 9.95 | 80.20 | 9.90 | 11.04 | 88.96 | 10.98 | 99.50 | 14.94 | 13.29 | 2.53 | |
| +600 | 714 | 11.10 | 78.20 | 10.80 | 12.43 | 87.57 | 12.09 | 97.30 | 9.01 | 7.89 | 1.50 | |
| +850 | 922 | 7.12 | 85.90 | 6.97 | 7.65 | 92.35 | 7.49 | 97.89 | 2.26 | 2.09 | .40 | |
| +1.00MM | 1086 | 8.43 | 83.60 | 8.02 | 9.16 | 90.84 | 8.71 | 95.14 | .86 | .78 | .15 | |
| +1.18 | 1285 | 15.50 | 69.40 | 15.10 | 18.26 | 81.74 | 17.79 | 97.42 | .22 | .18 | .03 | |
| +1.40 | 1543 | 3.62 | 93.30 | 3.04 | 3.74 | 96.26 | 3.14 | 83.98 | .07 | .07 | .01 | |
| +1.70 | 1844 | .00 | .00 | .00 | 50.00 | 50.00 | .00 | .00 | .02 | .01 | .00 | |
| +2.00 | 2173 | .04 | 100.00 | .00 | .04 | 99.96 | .00 | .00 | .01 | .01 | .00 | |
| +2.36 | 2571 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | | | | | | 100.02 | 88.29 | 16.78 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

FINES ROUGHER TAILINGS #5205

| FRACTIO | SYLVITE AREA % PLOTS | HALITE | SYLVITE | DISS. HALITE | HALITE | SYLVITE | DISS. HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .22 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 47.80 | 4.43 | 47.80 | 91.52 | 8.48 | 91.52 | 100.00 | 10.46 | .89 | .20 | |
| +75 | 126 | 49.90 | .22 | 49.90 | 99.56 | .44 | 99.56 | 100.00 | 35.11 | .15 | .03 | |
| +212 | 300 | 49.70 | .59 | 49.70 | 98.83 | 1.17 | 98.83 | 100.00 | 28.84 | .34 | .07 | |
| +425 | 505 | 49.80 | .39 | 49.80 | 99.22 | .78 | 99.22 | 100.00 | 13.80 | .11 | .02 | |
| +600 | 714 | 49.70 | .68 | 49.60 | 98.65 | 1.35 | 98.45 | 99.80 | 8.56 | .12 | .03 | |
| +850 | 922 | 48.90 | 2.81 | 48.30 | 94.57 | 5.43 | 93.41 | 98.77 | 2.02 | .11 | .02 | |
| +1.00MM | 1086 | 48.40 | 3.68 | 47.90 | 92.93 | 7.07 | 91.97 | 98.97 | .83 | .06 | .01 | |
| +1.18 | 1285 | 49.90 | 3.90 | 46.20 | 92.75 | 7.25 | 85.87 | 92.59 | .27 | .02 | .00 | |
| +1.40 | 1543 | 48.40 | 5.97 | 45.60 | 89.02 | 10.98 | 83.87 | 94.21 | .07 | .01 | .00 | |
| +1.70 | 1844 | 49.60 | .86 | 49.60 | 98.29 | 1.71 | 98.29 | 100.00 | .01 | .00 | .00 | |
| +2.00 | 2173 | 44.70 | 10.70 | 44.60 | 80.69 | 19.31 | 80.51 | 99.78 | .04 | .01 | .00 | |
| +2.36 | 2571 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | | | | | | 100.01 | 1.81 | .40 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

REGRIND ROUGHER FEED #5206

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS HALITE | HALITE | SYLVITE | DISS HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .37 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 44.70 | 10.60 | 44.70 | 80.83 | 19.17 | 80.83 | 100.00 | 8.24 | 1.58 | .58 | |
| +75 | 126 | 45.00 | 10.00 | 45.00 | 81.82 | 18.18 | 81.82 | 100.00 | 19.16 | 3.48 | 1.29 | |
| +212 | 300 | 46.40 | 7.20 | 46.40 | 86.57 | 13.43 | 86.57 | 100.00 | 23.54 | 3.16 | 1.17 | |
| +425 | 505 | 46.60 | 6.85 | 46.50 | 87.18 | 12.82 | 87.00 | 99.79 | 14.56 | 1.87 | .69 | |
| +600 | 714 | 46.60 | 6.90 | 46.50 | 87.10 | 12.90 | 86.92 | 99.79 | 15.36 | 1.98 | .73 | |
| +850 | 922 | 44.70 | 10.50 | 44.70 | 80.98 | 19.02 | 80.98 | 100.00 | 7.71 | 1.47 | .54 | |
| +1.00MM | 1086 | 43.90 | 12.20 | 43.90 | 78.25 | 21.75 | 78.25 | 100.00 | 5.77 | 1.25 | .46 | |
| +1.18 | 1285 | 43.60 | 12.80 | 43.60 | 77.30 | 22.70 | 77.30 | 100.00 | 3.61 | .82 | .30 | |
| +1.40 | 1543 | 43.30 | 15.90 | 40.80 | 73.14 | 26.86 | 68.92 | 94.23 | 1.73 | .46 | .17 | |
| +1.70 | 1844 | 44.90 | 10.20 | 44.90 | 81.49 | 18.51 | 81.49 | 100.00 | .23 | .04 | .02 | |
| +2.00 | 2173 | 44.40 | 11.20 | 44.40 | 79.86 | 20.14 | 79.86 | 100.00 | .08 | .02 | .01 | |
| +2.36 | 2571 | 31.30 | 68.50 | .23 | 31.36 | 68.64 | .23 | .73 | .01 | .01 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | | | | | | 100.00 | 16.14 | 5.97 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

REGRIND ROUGHER CONCENTRATE #5207

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS. HALITE | HALITE | SYLVITE | DISS. HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .07 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 23.70 | 52.90 | 23.40 | 30.94 | 69.06 | 30.55 | 98.73 | 7.64 | 5.28 | .37 | |
| +75 | 126 | 14.70 | 70.70 | 14.60 | 17.21 | 82.79 | 17.10 | 99.32 | 18.21 | 15.08 | 1.06 | |
| +212 | 300 | 21.30 | 57.40 | 21.30 | 27.06 | 72.94 | 27.06 | 100.00 | 23.00 | 16.78 | 1.17 | |
| +425 | 505 | 24.60 | 51.10 | 24.30 | 32.50 | 67.50 | 32.10 | 98.78 | 13.56 | 9.15 | .64 | |
| +600 | 714 | 18.90 | 63.00 | 18.10 | 23.08 | 76.92 | 22.10 | 95.77 | 15.98 | 12.29 | .86 | |
| +850 | 922 | 11.20 | 77.60 | 11.10 | 12.61 | 87.39 | 12.50 | 99.11 | 9.40 | 8.21 | .58 | |
| +1.00MM | 1086 | 12.30 | 75.50 | 12.20 | 14.01 | 85.99 | 13.90 | 99.19 | 7.06 | 6.07 | .42 | |
| +1.18 | 1285 | 42.20 | 15.80 | 42.00 | 72.76 | 27.24 | 72.41 | 99.53 | 3.28 | .89 | .06 | |
| +1.40 | 1543 | 36.60 | 29.00 | 34.50 | 55.79 | 44.21 | 52.59 | 94.26 | 1.66 | .73 | .05 | |
| +1.70 | 1844 | 4.57 | 90.90 | 4.52 | 4.79 | 95.21 | 4.73 | 98.91 | .20 | .19 | .01 | |
| +2.00 | 2173 | .32 | 99.50 | .20 | .32 | 99.68 | .20 | 63.84 | .02 | .02 | .00 | |
| +2.36 | 2571 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | | | | | | 100.01 | 74.70 | 5.23 | |

MODAL MINERALOGY OF DENISON POTACAN SAMPLES COLLECTED JUNE 8, 1988

REGRIND ROUGHER TAILINGS #5208

| SYLVITE FRACTIO | AREA % PLOTS | HALITE | SYLVITE | DISS. HALITE | HALITE | SYLVITE | DISS. HALITE | % HALITE DISSOL. | WT FACT. | MILL WEIGHTED | WT = SYLVITE | .30 AREA % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 NM | 53 | 46.70 | 6.76 | 46.50 | 87.36 | 12.64 | 86.98 | 99.57 | 12.02 | 1.52 | .46 | |
| +75 | 126 | 49.80 | .44 | 49.80 | 99.12 | .88 | 99.12 | 100.00 | 22.41 | .20 | .06 | |
| +212 | 300 | 49.90 | .14 | 49.90 | 99.73 | .27 | 99.73 | 100.00 | 23.05 | .06 | .02 | |
| +425 | 505 | 49.80 | .34 | 49.80 | 99.32 | .68 | 99.32 | 100.00 | 14.28 | .10 | .03 | |
| +600 | 714 | 49.60 | .88 | 49.60 | 98.26 | 1.74 | 98.26 | 100.00 | 14.47 | .25 | .08 | |
| +850 | 922 | 48.90 | 2.14 | 48.90 | 95.81 | 4.19 | 95.31 | 100.00 | 6.09 | .26 | .08 | |
| +1.00MM | 1086 | 48.50 | 3.48 | 48.00 | 93.31 | 6.69 | 92.34 | 98.97 | 4.13 | .28 | .08 | |
| +1.18 | 1285 | 47.70 | 4.67 | 47.70 | 91.08 | 8.92 | 91.08 | 100.00 | 2.27 | .20 | .06 | |
| +1.40 | 1543 | 47.40 | 5.41 | 47.20 | 89.76 | 10.24 | 89.38 | 99.58 | .94 | .10 | .03 | |
| +1.70 | 1844 | 43.60 | 12.80 | 43.60 | 77.30 | 22.70 | 77.30 | 100.00 | .25 | .06 | .02 | |
| +2.00 | 2173 | 37.60 | 25.00 | 37.30 | 60.06 | 39.94 | 59.58 | 99.20 | .08 | .03 | .01 | |
| +2.36 | 2571 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +2.80 | 3063 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| +3.35 | 4000 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | |
| | | | | | | | | | 99.99 | 3.05 | .91 | |

Liberation data for Denison Potacan Mill Samples Collected June 8, 1988.

COARSE ROUGHER FLOTATION FEED #5199

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS | CUM. % GR. SIZE DIST. | CUM. % WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 3.3e5 | 4.9e6 | 5.2e6 | 5.3e6 | 1.17 | 1.15 | 7.46 | 100.00 | 15.47 | 53 | 100.00 | 19.37 |
| +75 | 6.5e5 | 2.8e7 | 2.9e7 | 3e7 | 1.74 | 1.66 | 10.74 | 92.54 | 14.32 | 126 | 99.83 | 18.20 |
| +212 | 1.5e6 | 6.2e7 | 6.4e7 | 6.7e7 | 3.26 | 3.09 | 19.97 | 81.80 | 12.65 | 300 | 98.00 | 16.46 |
| +425 | 1.1e5 | 1.6e7 | 1.6e7 | 1.7e7 | 3.03 | 2.87 | 18.56 | 61.82 | 9.56 | 505 | 90.38 | 13.20 |
| +600 | 5.5e5 | 3.5e7 | 3.6e7 | 4.3e7 | 2.90 | 2.40 | 15.50 | 43.26 | 6.69 | 714 | 81.04 | 10.17 |
| +850 | 1.2e6 | 3e7 | 3.1e7 | 3.9e7 | 1.77 | 1.42 | 9.15 | 27.76 | 4.29 | 922 | 66.24 | 7.27 |
| +1000 | 1.9e6 | 2.3e7 | 2.5e7 | 3.5e7 | 1.31 | .93 | 6.02 | 18.61 | 2.88 | 1086 | 56.89 | 5.50 |
| +1180 | 1.4e6 | 1.2e7 | 1.3e7 | 2.2e7 | 1.05 | .64 | 4.13 | 12.59 | 1.95 | 1285 | 48.19 | 4.19 |
| +1400 | 7.6e6 | 1.5e7 | 2.3e7 | 5.8e7 | 1.22 | .48 | 3.09 | 8.45 | 1.31 | 1543 | 39.39 | 3.14 |
| +1700 | 7.2e6 | 1.4e7 | 2.1e7 | 5.6e7 | .61 | .23 | 1.49 | 5.36 | .83 | 1844 | 29.30 | 1.92 |
| +2000 | 9.5e6 | 1.3e7 | 2.3e7 | 5.4e7 | .68 | .28 | 1.83 | 3.87 | .60 | 2173 | 22.67 | 1.31 |
| +2360 | 9.9e5 | 3.6e7 | 3.7e7 | 6.2e7 | .45 | .27 | 1.74 | 2.04 | .32 | 2571 | 14.84 | .63 |
| +2800 | 1.9e6 | 1.1e7 | 1.3e7 | 4.1e7 | .15 | .05 | .31 | .31 | .05 | 3063 | 8.39 | .18 |
| +3350 | 0 | 0 | 0 | 4.4e6 | .03 | .00 | .00 | .00 | .00 | 4000 | 3.62 | .03 |
| | | | | | 19.37 | 15.47 | 100.00 | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

COARSE REAGENTIZING DRUM DISCHARGE #5200

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 3.3e5 | 3.7e6 | 4.0e6 | 4.4e6 | .78 | .71 | 5.04 | 100.00 | 14.16 | 53 |
| +75 | 5.3e5 | 2.3e7 | 2.4e7 | 2.4e7 | 1.27 | 1.25 | 8.79 | 94.96 | 13.45 | 126 |
| +212 | 9.4e5 | 6.3e7 | 6.4e7 | 6.7e7 | 3.03 | 2.89 | 20.41 | 86.17 | 12.21 | 300 |
| +425 | 4.7e5 | 4.2e7 | 4.2e7 | 4.5e7 | 2.59 | 2.44 | 17.26 | 65.75 | 9.31 | 505 |
| +600 | 1.6e6 | 4e7 | 4.2e7 | 4.9e7 | 3.06 | 2.60 | 18.34 | 48.50 | 6.87 | 714 |
| +850 | 3.7e5 | 2.1e7 | 2.1e7 | 3.1e7 | 1.30 | .90 | 6.33 | 30.15 | 4.27 | 922 |
| +1000 | 6.1e5 | 3e7 | 3.1e7 | 4.2e7 | 1.76 | 1.28 | 9.06 | 23.83 | 3.38 | 1086 |
| +1180 | 2.2e6 | 1.5e7 | 1.7e7 | 2.7e7 | 1.19 | .76 | 5.35 | 14.77 | 2.09 | 1285 |
| +1400 | 1.5e6 | 1.7e7 | 1.9e7 | 5.2e7 | 1.30 | .46 | 3.27 | 9.42 | 1.33 | 1543 |
| +1700 | 6.5e6 | 1.8e7 | 2.5e7 | 5.3e7 | .69 | .32 | 2.25 | 6.16 | .87 | 1844 |
| +2000 | 6.8e6 | 1.7e7 | 2.4e7 | 5.3e7 | .70 | .31 | 2.22 | 3.90 | .55 | 2173 |
| +2360 | 2e7 | 1.8e7 | 3.8e7 | 7.5e7 | .42 | .21 | 1.50 | 1.68 | .24 | 2571 |
| +2800 | 5.8e6 | 5.2e5 | 6.3e6 | 2.2e7 | .09 | .03 | .18 | .18 | .03 | 3063 |
| +3350 | 0 | 0 | 0 | 5.7e6 | .05 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 18.23 | 14.16 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

COARSE ROUGHER FLOTATION CONCENTRATE #5201

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 3e5 | 7e6 | 7.3e6 | 7.4e6 | .81 | .80 | 5.53 | 100.00 | 14.44 | 53 |
| +75 | 5e5 | 5.2e7 | 5.3e7 | 5.3e7 | 1.53 | 1.52 | 10.50 | 94.47 | 13.64 | 126 |
| +212 | 2.6e6 | 1.3e8 | 1.3e8 | 1.4e8 | 3.22 | 3.05 | 21.13 | 83.97 | 12.12 | 300 |
| +425 | 2.3e6 | 1e8 | 1.0e8 | 1.1e8 | 2.98 | 2.77 | 19.20 | 62.84 | 9.07 | 505 |
| +600 | 5.5e6 | 1e8 | 1.1e8 | 1.2e8 | 3.61 | 3.17 | 21.98 | 43.64 | 6.30 | 714 |
| +850 | 2.9e6 | 8.7e7 | 9.0e7 | 9.9e7 | 1.59 | 1.44 | 10.00 | 21.66 | 3.13 | 922 |
| +1000 | 8.2e6 | 8.1e7 | 8.9e7 | 9.7e7 | 1.01 | .93 | 6.43 | 11.66 | 1.68 | 1086 |
| +1180 | 5e6 | 6.8e7 | 7.3e7 | 7.6e7 | .55 | .53 | 3.66 | 5.22 | .75 | 1285 |
| +1400 | 1.1e7 | 1.4e8 | 1.5e8 | 1.6e8 | .21 | .20 | 1.37 | 1.57 | .23 | 1543 |
| +1700 | 8.2e6 | 4.1e7 | 4.9e7 | 5.5e7 | .03 | .03 | .19 | .19 | .03 | 1844 |
| +2000 | 2.4e6 | 3.7e6 | 6.1e6 | 6.2e6 | .00 | .00 | .01 | .01 | .00 | 2173 |
| +2360 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 2571 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 15.54 | 14.44 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

COARSE ROUGHER TAILS #5202

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 8.5e5 | 1.9e6 | 2.8e6 | 3.1e6 | .43 | .38 | 12.44 | 100.00 | 3.07 | 53 |
| +75 | 1.5e5 | 1.2e6 | 1.4e6 | 1.9e6 | .05 | .04 | 1.16 | 87.56 | 2.69 | 126 |
| +212 | 2.4e5 | 8.5e5 | 1.1e6 | 1.7e6 | .04 | .03 | .84 | 86.41 | 2.65 | 300 |
| +425 | 6.1e4 | 8.9e4 | 1.5e5 | 1.6e5 | .05 | .05 | 1.53 | 85.57 | 2.62 | 505 |
| +600 | 3.3e5 | 3.3e6 | 3.6e6 | 7.6e6 | .29 | .14 | 4.52 | 84.04 | 2.58 | 714 |
| +850 | 1.1e6 | 8.3e6 | 9.4e6 | 1.7e7 | .49 | .27 | 8.83 | 79.53 | 2.44 | 922 |
| +1000 | 8.6e5 | 1.5e7 | 1.6e7 | 2.5e7 | .91 | .58 | 18.82 | 70.69 | 2.17 | 1086 |
| +1180 | 3.2e6 | 1.2e7 | 1.5e7 | 2.2e7 | .83 | .57 | 18.70 | 51.87 | 1.59 | 1285 |
| +1400 | 4.1e6 | 8.3e6 | 1.2e7 | 3.9e7 | 1.03 | .33 | 10.68 | 33.18 | 1.02 | 1543 |
| +1700 | 7.5e6 | 1.8e7 | 2.6e7 | 5.9e7 | .77 | .33 | 10.85 | 22.50 | .69 | 1844 |
| +2000 | 5.3e6 | 1.3e7 | 1.8e7 | 5.2e7 | .64 | .23 | 7.34 | 11.65 | .36 | 2173 |
| +2360 | 2.1e6 | 1.2e7 | 1.4e7 | 5.1e7 | .30 | .08 | 2.70 | 4.31 | .13 | 2571 |
| +2800 | 8.9e6 | 3.2e6 | 1.2e7 | 4.1e7 | .16 | .05 | 1.54 | 1.60 | .05 | 3063 |
| +3350 | 1e6 | 0 | 1e6 | 2e7 | .04 | .00 | .07 | .07 | .00 | 4000 |
| | | | | | 6.03 | 3.07 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

FINES ROUGHER FEED #5203

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS | CUM. % GR. SIZE DIST. | CUM. % WEIGHTED SYLVITE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 4e5 | 3.4e6 | 3.8e6 | 3.9e6 | 1.50 | 1.46 | 9.06 | 100.00 | 16.13 | 53 | 100.00 | 17.60 |
| +75 | 6.2e5 | 2.5e7 | 2.6e7 | 2.7e7 | 6.05 | 5.74 | 35.58 | 90.94 | 14.67 | 126 | 99.90 | 16.10 |
| +212 | 1.2e6 | 6e7 | 6.1e7 | 6.7e7 | 5.88 | 5.37 | 33.29 | 55.36 | 8.93 | 300 | 98.76 | 10.05 |
| +425 | 1.5e6 | 3.9e7 | 4.1e7 | 4.6e7 | 2.31 | 2.03 | 12.61 | 22.07 | 3.56 | 505 | 80.16 | 4.17 |
| +600 | 9.8e5 | 4e7 | 4.1e7 | 4.9e7 | 1.36 | 1.14 | 7.05 | 9.46 | 1.53 | 714 | 67.42 | 1.86 |
| +850 | 1.7e6 | 3.1e7 | 3.3e7 | 4.1e7 | .32 | .26 | 1.58 | 2.41 | .39 | 922 | 47.36 | .50 |
| +1000 | 2.3e6 | 2.8e7 | 3.0e7 | 4.1e7 | .14 | .10 | .64 | .83 | .13 | 1086 | 36.71 | .18 |
| +1180 | 2.2e3 | 1.2e7 | 1.2e7 | 1.5e7 | .03 | .02 | .15 | .19 | .03 | 1285 | 27.61 | .04 |
| +1400 | 0 | 5.9e6 | 5.9e6 | 9.6e6 | .01 | .01 | .04 | .04 | .01 | 1543 | 19.95 | .01 |
| +1700 | 0 | 0 | 0 | 1.3e6 | .00 | .00 | .00 | .00 | .00 | 1844 | 11.74 | .00 |
| +2000 | 0 | 1.4e4 | 1.4e4 | 8.1e5 | .00 | .00 | .00 | .00 | .00 | 2173 | 7.89 | .00 |
| +2360 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 2571 | 4.42 | .00 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 | 2.23 | .00 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 | .86 | .00 |
| | | | | | 17.60 | 16.13 | | | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

FINES ROUGHER CONCENTRATE #5204

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.2e5 | 6.8e6 | 7.0e6 | 7.2e6 | 1.32 | 1.29 | 8.14 | 100.00 | 15.81 | 53 |
| +75 | 8.6e5 | 4.8e7 | 4.9e7 | 5e7 | 5.65 | 5.52 | 34.92 | 91.86 | 14.52 | 126 |
| +212 | 1.1e6 | 1.2e8 | 1.2e8 | 1.3e8 | 5.18 | 4.83 | 30.52 | 56.94 | 9.00 | 300 |
| +425 | 1.7e6 | 9.9e7 | 1.0e8 | 1.1e8 | 2.53 | 2.32 | 14.65 | 26.41 | 4.18 | 505 |
| +600 | 5e6 | 9.3e7 | 9.8e7 | 1.1e8 | 1.50 | 1.34 | 8.45 | 11.76 | 1.86 | 714 |
| +850 | 6.4e6 | 9.4e7 | 1.0e8 | 1.1e8 | .40 | .37 | 2.31 | 3.31 | .52 | 922 |
| +1000 | 8.1e6 | 8.9e7 | 9.7e7 | 1.1e8 | .15 | .13 | .84 | 1.00 | .16 | 1086 |
| +1180 | 0 | 0 | 0 | 1e-11 | .03 | .00 | .00 | .16 | .03 | 1285 |
| +1400 | 4.1e6 | 2.3e7 | 2.7e7 | 1.1e7 | .01 | .02 | .16 | .16 | .03 | 1543 |
| +1700 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .01 | .00 | 1844 |
| +2000 | 0 | 5.7e6 | 5.7e6 | 5.7e6 | .00 | .00 | .01 | .01 | .00 | 2173 |
| +2360 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 2571 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 16.77 | 15.81 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

FINES ROUGHER TAILINGS #5205

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 1.8e5 | 3.7e5 | 5.5e5 | 6.9e5 | .20 | .16 | 68.02 | 100.00 | .23 | 53 |
| +75 | 3.4e3 | 2.5e5 | 2.5e5 | 6.4e5 | .03 | .01 | 5.07 | 31.98 | .07 | 126 |
| +212 | 4e4 | 4.3e5 | 4.7e5 | 6.6e5 | .07 | .05 | 21.27 | 26.91 | .06 | 300 |
| +425 | 8.6e2 | 5.3e4 | 5.4e4 | 9.4e5 | .02 | .00 | .49 | 5.64 | .01 | 505 |
| +600 | 0 | 3.2e5 | 3.2e5 | 1.7e6 | .03 | .01 | 2.41 | 5.15 | .01 | 714 |
| +850 | 0 | 7.6e5 | 7.6e5 | 6.8e6 | .02 | .00 | .95 | 2.74 | .01 | 922 |
| +1000 | 8.1e2 | 2.5e6 | 2.5e6 | 7.9e6 | .01 | .00 | 1.35 | 1.79 | .00 | 1086 |
| +1180 | 0 | 1.5e6 | 1.5e6 | 3.5e6 | .00 | .00 | .18 | .44 | .00 | 1285 |
| +1400 | 5.3e5 | 8.9e5 | 1.4e6 | 2.4e6 | .00 | .00 | .25 | .25 | .00 | 1543 |
| +1700 | 0 | 0 | 0 | 4.2e4 | .00 | .00 | .00 | .00 | .00 | 1844 |
| +2000 | 0 | 0 | 0 | 1.5e4 | .00 | .00 | .00 | .00 | .00 | 2173 |
| +2360 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 2571 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | .38 | .23 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGRIND ROUGHER FEED #5206

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.5e5 | 1.1e6 | 1.4e6 | 1.5e6 | .58 | .52 | 10.92 | 100.00 | 4.78 | 53 |
| +75 | 6.3e5 | 8.7e6 | 9.3e6 | 9.8e6 | 1.29 | 1.23 | 25.70 | 89.08 | 4.26 | 126 |
| +212 | 4.3e5 | 1.9e7 | 1.9e7 | 2.1e7 | 1.17 | 1.08 | 22.66 | 63.37 | 3.03 | 300 |
| +425 | 7.1e5 | 1.2e7 | 1.3e7 | 1.5e7 | .69 | .58 | 12.24 | 40.72 | 1.95 | 505 |
| +600 | 1.5e6 | 1.2e7 | 1.4e7 | 1.9e7 | .73 | .52 | 10.86 | 28.48 | 1.36 | 714 |
| +850 | 2e6 | 1.7e7 | 1.9e7 | 2.7e7 | .54 | .38 | 7.95 | 17.63 | .84 | 922 |
| +1000 | 4.1e6 | 1.6e7 | 2.0e7 | 2.7e7 | .46 | .34 | 7.17 | 9.67 | .46 | 1086 |
| +1180 | 1.5e6 | 4.2e6 | 5.7e6 | 2.1e7 | .30 | .08 | 1.70 | 2.51 | .12 | 1285 |
| +1400 | 1.4e6 | 1.1e7 | 1.2e7 | 5.5e7 | .17 | .04 | .80 | .80 | .04 | 1543 |
| +1700 | 6.3e3 | 2.7e4 | 3.3e4 | 8.2e4 | .02 | .00 | .00 | .00 | .00 | 1844 |
| +2000 | 0 | 0 | 0 | 1.6e6 | .01 | .00 | .00 | .00 | .00 | 2173 |
| +2360 | 0 | 0 | 0 | 2.8e6 | .00 | .00 | .00 | .00 | .00 | 2571 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 5.96 | 4.78 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGRIND ROUGHER CONCENTRATE #5207

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 8.1e5 | 4.7e6 | 5.5e6 | 5.7e6 | .37 | .36 | 7.69 | 100.00 | 4.65 | 53 |
| +75 | 5.2e5 | 4.3e7 | 4.4e7 | 4.4e7 | 1.06 | 1.05 | 22.54 | 92.31 | 4.29 | 126 |
| +212 | 1.7e6 | 9.9e7 | 1.0e8 | 1.1e8 | 1.17 | 1.07 | 23.03 | 69.77 | 3.25 | 300 |
| +425 | 1.9e6 | 6.9e7 | 7.1e7 | 8.1e7 | .64 | .56 | 12.04 | 46.74 | 2.17 | 505 |
| +600 | 4.9e6 | 7.5e7 | 8.0e7 | 9.6e7 | .86 | .72 | 15.39 | 34.70 | 1.61 | 714 |
| +850 | 5.1e6 | 7.7e7 | 8.2e7 | 9.7e7 | .58 | .49 | 10.55 | 19.31 | .90 | 922 |
| +1000 | 4.9e6 | 6.7e7 | 7.2e7 | 9.1e7 | .42 | .33 | 7.13 | 8.76 | .41 | 1086 |
| +1180 | 2.4e6 | 2e7 | 2.2e7 | 5.6e7 | .06 | .02 | .52 | 1.62 | .08 | 1285 |
| +1400 | 6.1e6 | 1.4e7 | 2.0e7 | 2.4e7 | .05 | .04 | .90 | 1.11 | .05 | 1543 |
| +1700 | 3.6e6 | 3e7 | 3.4e7 | 3.9e7 | .01 | .01 | .19 | .21 | .01 | 1844 |
| +2000 | 0 | 1.1e7 | 1.1e7 | 1.1e7 | .00 | .00 | .02 | .02 | .00 | 2173 |
| +2360 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 2571 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | 5.22 | 4.65 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

REGRIND ROUGHER TAILINGS #5208

| SIZE FRACT | LIBERATION +86 % | +95 % | TOTAL | TOTAL AREA | WT FACT | WEIGHTED AREA % +86% LIB | +86 % NORMALIZED | +86 CUM % | +86% WT CUM | SIZE FOR PLOTS |
|---|---|---|---|---|---|---|---|---|---|---|
| -75 | 2.5e5 | 4.8e5 | 7.3e5 | 9.9e5 | .46 | .34 | 75.16 | 100.00 | .45 | 53 |
| +75 | 3.3e4 | 3.2e5 | 3.5e5 | 4.8e5 | .06 | .04 | 9.78 | 24.84 | .11 | 126 |
| +212 | 9.7e3 | 5.5e4 | 6.5e4 | 4.4e5 | .02 | .00 | .65 | 15.06 | .07 | 300 |
| +425 | 1.5e4 | 1.4e5 | 1.6e5 | 7.9e5 | .03 | .01 | 1.30 | 14.41 | .07 | 505 |
| +600 | 1.2e3 | 3.9e4 | 4.0e4 | 2.4e6 | .08 | .00 | .30 | 13.10 | .06 | 714 |
| +850 | 1.5e4 | 5.3e5 | 5.5e5 | 5.1e6 | .08 | .01 | 1.89 | 12.81 | .06 | 922 |
| +1000 | 1.1e4 | 1.3e6 | 1.3e6 | 7.4e6 | .08 | .01 | 3.14 | 10.91 | .05 | 1086 |
| +1180 | 0 | 1.7e6 | 1.7e6 | 8.4e6 | .06 | .01 | 2.69 | 7.77 | .04 | 1285 |
| +1400 | 2.7e6 | 5.8e6 | 8.5e6 | 1.8e7 | .03 | .01 | 3.14 | 5.08 | .02 | 1543 |
| +1700 | 1.5e6 | 4.2e6 | 5.7e6 | 2.1e7 | .02 | .01 | 1.20 | 1.94 | .01 | 1844 |
| +2000 | 4e6 | 0 | 4e6 | 1.2e7 | .01 | .00 | .74 | .74 | .00 | 2173 |
| +2360 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 2571 |
| +2800 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 3063 |
| +3350 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | .00 | 4000 |
| | | | | | .93 | .45 | | | | |

RESEARCH AND PRODUCTIVITY COUNCIL

# AUTHORIZATION

DEPARTMENT: MINERALS & FUEL TECHNOLOGY

PROJECT TITLE: "THE PETROLOGY, GEOCHEMISTRY AND MINERALOGY OF POTASH ORE MILL PRODUCTS FROM THE POTASH COMPANY OF AMERICA MINE AND THE DENISON POTACAN MINE"

PROJECT NUMBER: 08200812/0000 PROPOSAL NUMBER

REPORT M/89/07

Prepared By: _____
John A.R. Stirling
Section Head, Mineralogy

Reviewed By: _____
D. Abbott
Manager, R&D

Approved By: _____
M.D. Street
Head, Minerals & Fuel Technology

Date: August 3, 1989

**rpc** **RESEARCH AND PRODUCTIVITY COUNCIL**
P.O. Box 6000, Fredericton, New Brunswick, Canada, E3B 5H1
Telephone (506) 452-8994
Telex 014-46115
Fax (506) 452-1395